DOCUMENT RESUME

ED 187 572 SE 030 974

AUTHOR	Warfield, John N.
TITLE	Development of an Interpretive Structural Model and Strategies for Implementation Based on a Descriptive and Prescriptive Analysis of Resources for Environmental Education/Studies. A Sourcebook for the Design of a Regional Environmental Learning System, Volume VI: Content-Oriented Resources.
INSTITUTION	Virginia Univ., Charlottesville. School of Engineering and Applied Science.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Office of Environmental Education.
REPORT NO	UVA/522032/EE79/122
PUB DATE	31 Aug 79
CONTRACT	300-700-4028
NOTE	230p.; For related documents, see SE 030 969-973 and ED 173 172. Appendix A removed due to copyright restrictions.
EDRS PRICE	MF01/PC10 Plus Postage.
DESCRIPTORS	Change Strategies; *Curriculum Development; Educational Assessment; *Educational Needs; *Educational Planning; Educational Research; Elementary Secondary Education; *Environmental Education; *Interdisciplinary Approach; Mathematics Education; Mathematics Instruction; Models; *Science Education

ABSTRACT

Reported are possible methods for integrating environmental education into existing public school curricula. This volume proposes a technique called "piggy-backing" by which environmental education may be integrated into existing curricula with none or very little increase in teacher work loads and per pupil cost. Examples of integration include discussion for eighth-grade mathematics. Specific mathematics problem sets are described which deal with energy and environmental issues. (RE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED187572

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

RESEARCH LABORATORIES FOR THE ENGINEERING SCIENCES

SCHOOL OF ENGINEERING AND APPLIED SCIENCE

UNIVERSITY OF VIRGINIA

Charlottesville, Virginia 22901

DEVELOPMENT OF AN INTERPRETIVE STRUCTURAL MODEL AND STRATEGIES FOR IMPLEMENTATION BASED ON DESCRIPTIVE AND PRESCRIPTIVE ANALYSIS OF RESOURCES FOR ENVIRONMENTAL EDUCATION/STUDIES

VOLUME VI

CONTENT-ORIENTED RESOURCES

Submitted to:

Office of Environmental Educaton
Department of Health, Education and Welfare
400 Maryland Avenue, S.W.
FOB #6, Room 2025
Washington, D. C. 20202

Submitted by:

John N. Warfield

Report No. UVA/522032/EE79/122

August 1979

SE 030 974

RESEARCH LABORATORIES FOR THE ENGINEERING SCIENCES

Members of the faculty who teach at the undergraduate and graduate levels and a number of professional engineers and scientists whose primary activity is research generate and conduct the investigations that make up the school's research program. The School of Engineering and Applied Science of the University of Virginia believes that research goes hand in hand with teaching. Early in the development of its graduate training program, the School recognized that men and women engaged in research should be as free as possible of the administrative duties involved in sponsored research. In 1959, therefore, the Research Laboratories for the Engineering Sciences (RLES) was established and assigned the administrative responsibility for such research within the School.

The director of RLES—himself a faculty member and researcher—maintains familiarity with the support requirements of the research under way. He is aided by an Academic Advisory Committee made up of a faculty representative from each academic department of the School. This Committee serves to inform RLES of the needs and perspectives of the research program.

In addition to administrative support, RLES is charged with providing certain technical assistance. Because it is not practical for each department to become self-sufficient in all phases of the supporting technology essential to present-day research, RLES makes services available through the following support groups: Machine Shop, Instrumentation, Facilities Services, Publications (including photographic facilities), and Computer Terminal Maintenance.

DEVELOPMENT OF AN INTERPRETIVE STRUCTURAL MODEL AND STRATEGIES FOR IMPLEMENTATION BASED ON A DESCRIPTIVE AND PRESCRIPTIVE ANALYSIS OF RESOURCES FOR ENVIRONMENTAL EDUCATION/STUDIES

A SOURCEBOOK FOR THE DESIGN OF A REGIONAL ENVIRONMENTAL LEARNING SYSTEM

VOLUME VI

CONTENT-ORIENTED RESOURCES

Contract No. 300-700-4028

Work Supported Under the
Environmental Education Act of 1970
P. L. No. 91-516,
P. L. No. 93-278 and P. L. No. 95-482, as amended

Submitted to:

Office of Environmental Education
Department of Health, Education and Welfare
400 Maryland Avenue, S.W.
FOB #6, Room 2025
Washington, D. C. 20202

Submitted by:

John N. Warfield

Department of Electrical Engineering
RESEARCH LABORATORIES FOR THE ENGINEERING SCIENCES
SCHOOL OF ENGINEERING AND APPLIED SCIENCE
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VIRGINIA

Report No. UVA/522032/EE79/122 Copy No._____

August 31, 1979

A SOURCEBOOK FOR THE DESIGN OF A REGIONAL ENVIRONMENTAL LEARNING SYSTEM

VOLUME 6

CONTENT-ORIENTED RESOURCES

TABLE OF CONTENTS

PREFACE

EXECUTIVE SUMMARY

Chapter 1. Synthesizing Environmental Education with Mathematics Education

Chapter 2. An Exploration of the Study of Human Settlements at the Secondary Level

Appendix A Some Principles of Knowledge Organization

Appendix B An Introduction to Environmental Education Teacher Training Resources

A SOURCEBOOK FOR THE DESIGN OF A REGIONAL ENVIRONMENTAL LEARNING SYSTEM

VOLUME VI: CONTENT-ORIENTED RESOURCES

PREFACE

This is one of six Volumes of a report which, collectively, is intended to be a Sourcebook for the Design of a Regional Environmental Learning System. The report was prepared under Contract 300-700-4028 with the Office of Environmental Education.

This six-volume report presumes some background concerning the concept of a Regional Environmental Learning System, and with environmental education as a whole. Considerable relevant background was supplied in Volume 9 of the 4th Quarterly Report (A Descriptive Analysis of Environmental Education) and in the 5th Quarterly Report (Conceptual Basis for the Design of Regional Environmental Learning Systems), both of which are available from the Office of Environmental Education.

Volume 1 contains an Overview of the Sourcebook, with short summaries of the other Volumes.

A SOURCEBOOK FOR THE DESIGN OF A REGIONAL ENVIRONMENTAL LEARNING SYSTEM

VOLUME 6: CONTENT-ORIENTED RESOURCES

EXECUTIVE SUMMARY

This Volume 6 of the Sourcebook for the Design of a Regional Environmental Learning System should be seen in the perspective of the larger program of the Office of Environmental Education. The contract under which this Volume was developed was not intended to focus upon the development of content materials for environmental education. Other efforts sponsored by the Office of Environmental Education were targeted toward the development of content materials.

What is presented in this Volume should be viewed as a modest additional contribution to the general thrust of development of content materials, along with a specific reference to a major content-development activity (in Appendix B).

Early in our project, it was noted that there was considerable public dissatisfaction with the problems accompanying some of the mathematics curricula. These problems tended to emphasize particular foods that many believed were being promoted for child use by their inclusion in the mathematics curricula. Dr. Robert Waller of the University of Northern Iowa felt that it would be appropriate to replace such problems with problems that provided environmental education. Accordingly he was authorized to explore the possibility of developing a set of problems that could be used in the mathematics curriculum. Dr. Waller has a strong personal interest in wood-burning stoves, since in his Iowa situation he finds that wood-burning stoves offer an alternative means of providing heat in winter. The problems that he has developed focus on wood. There is both an advantage and a disadvantage here. The advantage is that many different environmental ideas can be treated, with minimum demands on particular environmental areas, and this lends itself to use in the mathematics curriculum. The disadvantage, from a broad environmental perspective is the narrowness of the subject.

On balance, it is felt that the use of wood as a primary topic for the problems has considerably more advantages than disadvantages.

Dr. Waller and his colleague have produced a set of problems, centered around the Scott, Foresman and Company textbook series, and designed for eighth graders. By tying the problems to a rather widely used textbook, teachers will be able to take advantage of the sequence displayed therein to judge how to use the problems in any other text that they may be using.

Most of the problems are quantitative. However a few are qualitative, involving the logical structure of issues. It is felt that students at eighth grade level are ready to begin to work with qualitative, logical structuring of issues.

All of the foregoing appears in Chapter 1 of the report, which has its own table of contents.

In Chapter 2, the primary concern is with how knowledge is organized for learning and for retrieval. In this Chapter, attention is focused primarily on the proposed core theme of "human settlements". The science of human settlements, ekistics, is examined to see whether there is or can be formed a suitable typology for this subject, so that the organization and teaching of the subject can eventually become more organized. A typology is developed and presented in this Chapter. It is built largely around the Doxiadis ekistics grid. Also the organization and classification of articles appearing in selected issues of the Journal of Environmental Education is discussed, from the perspective of how this journal might be useful in developing content materials for environmental education.

In Appendix A there is a technical paper showing some principles of knowledge organization that were used in exploring the typology of human settlements.

In Appendix B, there is a short description of a significant development of content materials. These materials, developed around the concept of energy, are intended to be used in both preservice and inservice teacher training. The Appendix gives a description of the several volumes that are available, and provides ordering and approximate cost information. This material was developed by the Far West Laboratory for Educational R&D, with support from OEE.

CHAPTER 1

SYNTHESIZING ENVIRONMENTAL EDUCATION WITH MATHEMATICS EDUCATION

Robert J. Waller

James M. Wilmesmeier

Subcontractor's report under "Development of an Interpretive Structural Model and Strategies for Implementation Based on a Descriptive and Prescriptive Analysis of Resources for Environmental Education/Studies."

August, 1979

CONTENTS

Introduction 1

Piggybacking 2

Current Trends in Mathematics Education 4

Problem Set #1 7

Problem Set #2 68

The Strategy 81

Conclusion 82

SYNTHESIZING ENVIRONMENTAL EDUCATION WITH MATHEMATICS EDUCATION

Robert J. Waller
James M. Wilmesmeier

The overriding purpose of "Development of an Interpretive Structural Model and Strategies for Implementation Based on a Descriptive and Prescriptive Analysis of Resources for Environmental Education/ Studies" is to improve the quality of environmental education in America. Those involved in this project recognize, correctly, that environmental education occurs in both formal settings (educational institutions) and informal settings (community seminars, local and regional task forces, etc). This report focuses on the former -- environmental education in the public school system.

More specifically, the purpose here is to provide at least partial answers to the following questions:

1. How can environmental education gain entry into already overloaded public school systems?

2. How can people be helped to think clearly about complex environmental problems? (This dilemma is also present in informal settings.)

The response to the first question thus far has been to attempt to integrate it (environmental education) into the natural science curriculum. The second question, to the best of the authors' knowledge, has not even been addressed. It is our contention that the problems posed by each of these questions may be solved simultaneously. The idea we propose will be called "piggybacking." We discuss this idea

in the next section of the report.

PIGGYBACKING

Certain subject matters — such as mathematics, music, art, and English — are not restricted to any particular content or context. A few simple examples will make this clear. Basic mathematical ideas such as addition, algebra, and calculus are used in the diverse fields of science, business, and engineering. Even though the content being handled differs, the mathematics remains the same. For example, an equation such as $Y = 6X$ can be used to solve certain problems in each of these fields. The content and context change, but the basic mathematical structure does not.

Likewise, thousands of songs can be sung to a $C - F - G_7 - C$ chord progression. These songs can encompass love, or war, or the sea, or the land, or the railroads, yet the underlying chord structure remains the same. It should be obvious that the visual arts and English also have properties similar to mathematics and music. All of these subjects are, in a sense, languages that can be used to "discuss" many contents in many contexts, just as a metalsmith's skills can be used to build swords or plowshares.

Thus, any of the subjects just mentioned could be used as the focus of this report. We have chosen mathematics since, as teachers of applied mathematics, it is the one with which we are most familiar.

In brief, then, we believe the following to be both true and feasible: Environmental concepts and ways of thinking about environmental problems can be piggybacked on to the existing public school system mathematics curriculum with zero (or very little) net gain in teacher work loads and per pupil cost. The remainder of this report will provide some philosophy and illustrations of how this might be accomplished. Before we turn to these tasks, however, two caveats are in order.

First, we are not public school teachers of mathematics. Hence, we recognize our considerable ignorance of such issues as how mathematics may best be taught at the elementary and secondary levels and learner readiness for the various mathematical concepts. We have no desire to enter such arenas, and we will make every attempt not to do so. Second, certain environmental issues (e.g., energy) are politically explosive. Such considerations also are not our domain. We trust that textbook publishers and authors know how to deal with these sorts of problems.

In short, our purpose is to demonstrate the feasibility of an idea. Development and implementation must be left to professionals in primary and secondary mathematics education. To attempt more would exceed both our competence and our funding.

Our discussion in the remainder of this report will focus on mathematics as it is taught in grades K-8. There are two reasons for this restriction. First, we take it as axiomatic that students should

be exposed to environmental ideas early on. Second, most K-8 mathematics curricula are built around one of the several mathematics series produced by various publishers. An attempt is made in each of these series to achieve some reasonable level of conceptual integration from kindergarten through the eighth grade. In terms of environmental education, this series approach provides a rich opportunity for key environmental concepts to make repeated appearances year after year as the student moves through the K-8 sequence. Our focus on K-8 in this report is not meant to imply that environmental education should stop at eighth grade. In fact, we would argue that the increased intellectual maturity of the high school student should allow some rather sophisticated coverage of environmental ideas. But, because all (or most) students in a given public school system generally study the same texts, it is the K-8 sequence where the foundations of environmental education can best be laid.

CURRENT TRENDS IN MATHEMATICS EDUCATION

It is convenient for our purposes to break down the totality of mathematical ideas into three somewhat overlapping categories:

1. Quantitative or Numerical Mathematics. Those branches of mathematics dealing with space, numbers and numerical manipulation (computation). Examples: Addition, subtraction, multiplication, division, decimals, fractions, measurement, algebra, geometry, trigonometry, calculus.

2. The Mathematics of Uncertainty. Examples: statistics, probability.

3. Qualitative or Non-Numerical Mathematics. Those branches of mathematics dealing with situations where questions of space and numerical magnitude are either absent or irrelevant. Examples: sorting and classifying objects, set theory in general, ordering, relations.

Even a cursory examination of the various leading mathematics textbook series discloses that category one, numerical mathematics, receives the dominant emphasis in the elementary and intermediate grades. Statistical concepts, such as measuring objects and using graphs are sprinkled throughout the concepts taught in grades K-8, and probability makes an appearance in grades 7 or 8. Qualitative mathematics is introduced as early as kindergarten, in the form of sorting and classifying, but overall receives little attention in grades K-8.

This current neglect of qualitative mathematics in the K-8 curriculum apparently stems from two sources. First, the emphasis on computational skills is symptomatic of the "back to basics" movement that presently seems to pervade public school systems in general. Second, and more specific to mathematics education, the much-publicized failure of the "new math" has generated a strong counter movement. Since many of the key ideas in qualitative mathematics were closely associated with the new math enterprise (e.g., set theory), the result of the backlash has been the virtual banishment of qualitative mathematics from public school curriculums.

We find the neglect of qualitative mathematics and the relatively small amount of attention given to the mathematics of uncertainty in

K-8 distressing. Both of these areas of mathematics are invaluable for dealing with problems involving complexity and uncertainty -- features that characterize most of our contemporary personal, social, and environmental dilemmas. Moreover, the Environmental Education Act itself is quite specific in its insistence that interrelationships among various environmental systems and subsystems be emphasized. Hence, at the very time when abilities for dealing with complexity and uncertainty are most needed among our citizenry, the public school mathematics curriculums have moved in the opposite direction.

This complicated our work considerably. In fact, we were confronted with the following dilemma. Should we simply ignore current trends in mathematics curricula and demonstrate the usefulness of all three previously-mentioned categories of mathematics for conveying environmental concepts, or should we attempt to live within the structures imposed by the current trends in mathematics education? The first approach, we felt, would be more interesting and useful, the second more practical in terms of gaining acceptance of the ideas espoused here.

We decided upon the following approach. We would write a problem set involving environmental concepts using only those mathematical ideas found in one of the current mathematics textbook series. The purpose was to demonstrate that some environmental education could be piggybacked onto a mathematics curriculum composed mostly of numerical mathematics. This approach has the advantage of not trying to create

a revolution in mathematics education at the same time we are trying to demonstrate the feasibility of piggybacking.

Beyond this, however, we also have developed a second shorter problem set that makes use of some key ideas in qualitative mathematics and the mathematics of uncertainty. The purpose in doing this is to demonstrate that if one is really interested in conveying the essential nature of environmental complexity, something beyond straight numerical concepts are needed.

Problem Set #1

Background Information

The notion of a person's environment is a rich lode of topics that can be used to generate mathematics problems. One can select a specific river basin as a vehicle for writing a series of problems or simply use river basins in general. Similarly, forests, oceans, energy, and so forth can be treated at various levels of specificity. In addition, if environmental education is construed as encompassing a person's socio-economic environment, which we think is appropriate, the opportunities for developing mathematical problems increase substantially.

For our first problem set, we chose the general topic of energy. Our reasons for choosing energy were not complex. First of all, it is timely. Second, we felt this topic would provide many opportunities for writing problems in numerical mathematics.

Within this very large topic of energy, we focused on home heating. Specifically, we decided to deal with one type of energy used in home heating sytems: wood. The justification for this choice is discussed next.

To some, wood as a source of home heating probably seems quaint, if not downright barbaric. As one of the authors of this report can testify, however, it is a perfectly practical way of supplying all or part of one's heating requirements. As late as 1860, wood accounted for 90 percent of the energy consumed in the United States. But, the relative convenience of electricity, oil, and natural gas has resulted in these forms of home heating being preferred to wood in the last century. This, however, is changing.

The rapidly escalating costs of fossil fuels have caused a resurgence in the use of wood as a source of home heating. Some estimates indicate that perhaps 25 percent of the homes in the Northeastern United States now have a woodburning unit supplying all or part of the home heating requirements. Moreover, the modern airtight high-efficiency woodburning stoves and furnaces bear little resemblance to the old pot bellied stoves many people still associate with wood heat.

As a source of problems to illustrate how environmental concepts can be conveyed via mathematics, the use of wood heat had many advantages for us. First, it is a small enough topic that we could be rather thorough in our coverage of it, even given the relatively short time span we had to develop the problem set. A second advantage is that

the ideas of trees, woodburning stoves, chimneys, and so forth are fairly concrete. That is, students should be able to grasp the essential features of a woodburning operation. The same cannot be said of topics such as OPEC and heat pumps. These latter topics, we emphasize, can be grasped by students. But, for an introductory problem set, the notions surrounding wood heat are somewhat more straightforward.

A third advantage is that it is easy to conceptualize an entire series of transformations beginning with trees in a forest and ending with the production of heat. All people who burn wood seriously are very aware of this process. Going out to the woodpile in the middle of a midwestern blizzard is just not the same as turning up the thermostat.

Finally, if you really think about it, you can see that a rich assortment of topics can be spun off from the simple idea of heating with wood. These range all the way from woodlot management and forestry to watersheds, to wildlife management, to comparisons with other forms of energy in terms of cost and efficiency, to the economics of family management. In this sense, wood heating is like almost any other topic in environmental education: One starts with a small idea and a universe of systems and subsystems can be built from it. We are, it should be noted, not touting wood heat as <u>the</u> best method for piggybacking environment concepts onto mathematics education. We are simply saying that it seems to be a good one for our purposes here.

The problem set that follows contains some 200 problems. Each of

these deals directly with the idea of heating with wood. The problems were developed using Mathematics Around Us, a textbook series authored cooperatively by 10 people and published by Scott, Foresman, and Company (Copyright 1978, used by permission). We chose to use this series simply because it is quite typical of such series and because it is the text used in the Cedar Falls, Iowa, public schools, which made it easily available to us, since that is where we reside.

We elected to use the book designed for grade eight in the K-8 sequence. Admittedly, this provided us with some nice latitude, since the student at this level can be assumed to have some familiarity with a fairly broad range of mathematical ideas. We would contend, however, that 80 percent of the problems we developed are easily adaptable to lower grade levels with a minimum of reworking.

Our approach was simple. We went through the text, and at each place where problems were presented in a "theme" context, we rewrote these problems in terms of heating with wood. Thus, for example, where the book used the theme of postal services to illustrate "Multiplying Whole Numbers", we used a problem involving computation of a utility bill.

The text is lavishly illustrated, containing notes and pictures that provide the student with enough written and visual information to put the problems into the theme context. A text incorporating wood heat in a number of theme contexts would have pictures of stoves, installations, chainsaws, forests, and so forth. Obviously, we do not

provide these in our problem set. But the reader should be aware that we assume they would be provided if our problems were to appear in textbook form.

The Problems

Multiplying Whole Numbers

Pages 10-11

1. Mr. Jones has just received his bill for natural gas from the gas company. Last month he used $127.00 worth of gas. If he uses this much for five months, how much will he spend on gas for the five months?

Estimating

Pages 12-13

1. Tom's father owns 20 acres of timber. If each acre has about 150 trees on it, about how many trees does Tom's father own?
2. About ten trees are destroyed by insects each month. How many trees will be destroyed in one year?
3. There are about 30 animals per acre in the forest. How many animals live in Tom's father's forest?

Division, Careers

Pages 18-19
Page 22 Careers

1. Jim's mother owns a store where she sells equipment for cutting fire wood. Last year she sold 432 axes in 12 months. How many axes did she sell per month on the average?
2. Jim helps his mother sharpen chain saws. A chain saw blade has 32 teeth. It takes Jim 10 minutes to sharpen one blade. How many teeth does he sharpen each minute on the average?
3. If Jim can wait on a customer every 15 minutes, how many customers can Jim wait on in three hours?

   These are the prices of some of the items sold in the store:

Axe	$ 18
Chain Saw	$200
Gas Can	$ 2
Splitting Maul	$ 20
Safety Helmet	$ 27

4. If a customer wants to buy an axe and a splitting maul, how much should Jim charge the customer?
5. If another customer wants to buy a chain saw, a gas can, and a safety helmet, how much should Jim charge the customer?
6. For the chain saws to run properly, 32 ounces of gas must be mixed with one ounce of oil. If a gallon of gas weighs 128 ounces, how many ounces of oil must be mixed with the gallon of gas?

Writing Addition and Subtraction Expressions

Pages 26-27

Write a mathematical expression for each description.

1. The price of a professional chain saw that costs n dollars more than a $100 regular chain saw.
2. The weight of a regular chain saw if it weighs six pounds less than a professional chain saw weighing g pounds.
3. The sale price of a professional chain saw if the regular price of $312 has been reduced by d dollars.
4. The total length of a chain saw if the motor and handle measure 18 inches and the bar measures n inches.

Solving Addition and Subtraction Equations

Pages 28-29

Jim's mother also sells wood burning stoves in her store.

1. One of the large stoves she sells is 14 inches wider than a smaller stove. If the large stove is 37 inches wide, how wide is the small stove?
2. The weight of a small stove is 128 pounds less than the weight of a large stove. The small stove weighs 135 pounds. How much does the large stove weigh?

Using Addition and Subtraction Equations to Solve Problems

Pages 30-31

Part of the heat in Sue's house comes from a wood-burning stove. It is Sue's job to help tend the stove.

1. Before the stove was installed, it took 7000 kilowatt hours per month to heat Sue's house. Now it takes 1700 kilowatt hours per month. How many hours per month does the stove save.
2. Sue went to the woodbox in the basement and brought 11 pieces of wood upstairs for the stove. There are 74 pieces left in the wood-box. How many pieces were in the woodbox before Sue took out the 11 pieces?
3. The stove in Sue's house takes pieces of wood up to 24 inches in length. One piece in the woodbox is 31 inches long. How many inches must be cut off before the piece of wood will fit in the stove?
4. When the stove is full of wood, it weighs 315 pounds. It holds about 45 pounds of wood. How much does the stove weigh empty?

Careers

Pages 32-33

1. A wood supplier sells wood to people who have woodburning stoves. The table shows his sales last winter. The price per pick-up load varies based on the month of the year. Complete the table.

Month	Number of Pick-up loads	Price per Pick-up load	Total Sales
October	30	$35	
November	35	$40	
December	47	$45	
January	54	$48	
February	43	$45	
March	24	$30	

Total sales for the Winter _____

2. For every load of fire wood delivered, it costs the supplier $1.15 in gas and oil for his truck. How much did he spend delivering February's wood?
3. The supplier sometimes hires a junior high school student to help him. He pays the student $2.80 for each load he helps deliver. If the student helped deliver 15 loads in March, how much did he earn?
4. If it takes the supplier an average of 40 minutes to deliver a load of wood, how many loads can be delivered in an eight-hour day?
5. Find the total cost of equipment for the fire wood supplier (aside from his truck).

Number of Items	Item	Cost Per Item	Total Cost
1	Chain Saw	$312	
2	Splitting Mauls	18	
3	Splitting Wedges	7	
2	Gas Cans	2	
1	Safety Helmet	27	
3	Sharpening Files	1	
1	Sharpening Guide	3	
2	Axes	18	
1	Hydraulic Splitter	600	

Total Cost of Equipment_____

Writing Multiplication and Division Expressions

Pages 34-35

Write a mathematical expression for each description.

1. The height of a full-grown Oak tree if it is three times as tall as a partially-grown tree that is n feet tall.
2. The diameter of a full-grown Oak tree if it grows one inch in diameter for each of the 35 years it grows.
3. The number of trees cut for fire wood each year if n trees are cut from each acre of a 12 acre parcel of timber.

Solving Multiplication and Division Equations

Pages 36-37

1. Bob wants to be sure he replaces the wood he burns in his stove. He has 15 acres of land and 75 young trees to plant. How many trees will each acre get if Bob wants to make sure each acre gets the same number?
2. Bob sprinkles the ashes left from burning his wood on his garden, since the ashes make good fertilizer. He has 56 pounds of ashes and his garden has 8 rows. How many pounds per row should he use if each row is to receive the same amount?

Using Multiplication and Division Equations to Solve Problems

Pages 38-39

1. How long does it take to burn 140 pounds of wood if it burns at a rate of 5 pounds per hour in a certain wood stove?
2. If an acre of ground contains 75 pick-up loads of wood, how many years will the wood last if 15 pick-up loads a year are taken out of the acre?
3. If a man with a chain saw can cut four pick-up loads of wood per day, how many pick-up loads can he cut in 135 days?
4. If an acre of woods can shelter 45 animals, how many acres would it take to shelter 405 animals?
5. How much gas is used by a chain saw in an eight-hour day if it takes two hours to use a gallon of gas?

Equations Involving Multiplication and Addition

Pages 42-43

1. Rachael is planting young walnut trees on some land she owns. She has planted 150 trees in three hours. At this rate, how many hours will it take her to plant 1000 trees?
2. The 150 trees Rachael has planted cost her 4¢ per tree. How many more trees will she have to plant to reach $20 worth of planted trees?

Equations Involving Multiplication and Subtraction

Pages 44-45

1. Todd helps his neighbor cut wood on Saturdays. He is paid $2.00 per hour. In order to get this job, Todd had to buy a safety helmet, gloves, and steel-toed shoes. These three items cost him $66. How many hours must Todd work to make a profit of $30.
2. If Todd earned $2.50 per hour, how long would he have to work to make a profit of $30.

Adding and Subtracting Integers

Pages 50-54

1. Tom is helping a friend install a wood stove. When they stopped work on Monday night, the chimney flue was two feet below the roof. The next day they added six feet more of flue. How far above the roof is the top of the flue.

2. The temperature outside was 12 degrees below zero at 7:00 a.m. It had risen 16 degrees by noon. What was the temperature at noon?

3. When the woodburning stove was finally installed and operating, the temperature in the room rose from 55° to 78°. What was the rise in temperature?

Comparing and Ordering Decimals

Pages 74-75

1. Here are some times showing the length of time in hours four woodburning stoves kept going on a full load of wood.

Stove A	14.68 hours
Stove B	13.52 hours
Stove C	14.89 hours
Stove D	14.48 hours

List the stoves and their burning times in order starting with the lowest.

2. Different types of woodburning stoves begin to give off heat faster than others once they have been started. Here are five stoves and the time it takes for each of them to start giving off heat.

Stove A	2:14.08
Stove B	3:02.16
Stove C	2:12.14
Stove C	2:16.19
Stove D	2:48.22

List the stoves and their times in order. Begin with the lowest.

3. Electricity is priced on the basis of cents per kilowatt hour. Here are the prices of electricity in three cities.

City A	$ .0430
City B	$ .0436
City C	$ .0429

List these cities in order. Start with the highest-priced city.

4. Round the prices given in problem 3 to the nearest cent.

Scientific Notation: Large Numbers

Pages 80-81

Authors' note: The "theme" used here by the text is power generation by a power company. The problems given would fit nicely into our scheme and, hence, no new problems are presented here.

Adding and Subtracting Decimals

Pages 86-87

As was true with the scientific notation, the problems presented here center around a theme (snowfall) that fits nicely with our scheme. Hence, no new problems are presented here.

Using Equations To Solve Problems

Pages 88-89

1. John's woodburning stove will take logs up to 60.96 centimeters in

length. One log in John's woodpile is 71.35 centimeters long. How many centimeters must John cut off of this log in order for it to fit his stove?

2. One tree in John's woodlot is 15.2 meters high. The distance from the ground to the first limb is 5.8 meters. How far is it from the first limb to the top of the tree?
3. One of the trees in John's woodlot is 13.3 meters high. Last year it was 12.82 meters high. How much did the tree grow in one year?
4. John cut down a tree and sold it for firewood. He received $32 for it. He used $1.78 worth of gas and oil in cutting the tree. What was John's profit?

Estimating Sums

Pages 90-91

Tracy has bought some items at the local shop selling equipment for woodcutting. While she waits for the salesperson to find the actual cost, she estimates the cost herself. Using rounding, estimate the cost of Tracy's purchases.

Actual Cost	Estimated Cost
3.41	
6.12	
.89	
Actual Total	Estimated Total

Using Multiplication

Page 93

1. A section of stovepipe is 30 inches long. How many inches of stovepipe are needed if a particular installation requires 12 sections?
2. In problem 1, what will the total cost of stovepipe be if each section costs $7.80?

Dividing a Decimal by a Whole Number

Page 96

1. Five 30 inch lengths of insulated fluepipe cost a total of $162.50. Find the cost per inch.
2. 128 ounces of oil for a chain saw bar cost $2.29. Find the cost per ounce.
3. 6 gallons of gas purchased to fuel a chainsaw cost $5.60. Find the cost per gallon.

Dividing Decimals by Decimals

1. A stack of tree leaves has 945 leaves in it. The stack is 4.8 centimeters thick. Find the thickness of one leaf.
2. The gas tank on a certain chainsaw holds 20.58 fluid ounces of a gas-oil mixture. A can contains 132.68 ounces of this mixture. How many times can the tank be filled using the contents of the can?

Rounding Quotients

Page 98

1. Andy paid $117 for three pickup loads of wood. Find the price per pickup load. Round to the nearest dollar.
2. A "face cord" of wood is a stack of wood four feet high, two feet wide, and eight feet long. Dave paid $137 for three face cords. Find the price per face cord. Round to the nearest dollar.
3. Last winter, John used 26,321 total kilowatt hours of electricity to heat his house during the months of November, December, January, February, and March. Find the average use per month. Round to the nearest kilowatt hour.

Formulas Involving Decimals

Pages 100-101

1. 5000 kilowatt hours of electricity cost $234.45 in a midwestern city last year. Find the cost per kilowatt hour. Round to the nearest cent.

Metric Units of Length

Pages 108-109

1. A face cord of wood is 2.432 meters long. Express this in centimeters.
2. The diameter of a particular piece of stovepipe is 15.24 centimeters. Express this in decimeters.

Metric Units of Area

Pages 110-111

1. The top surface of a particular wood stove is 55.88 centimeters wide and 88.9 centimeters long. What is the area in centimeters of this surface?
2. A second stove is 5588 millimeters wide and 8890 millimeters long. Find the area of the top surface of this stove. Give your answer in square centimeters.

Metric Units of Volume

Pages 112-113

1. A cord of wood is a stack 1.216 meters high, 1.216 meters wide, and 2.432 meters long. What is the volume of a cord of wood? Give your answer in millimeters.
2. A face cord of wood is a stack 1.216 meters high, .608 meters wide, and 2.432 meters long. What is the volume of a face cord of wood. Express your answer in millimeters.
3. A certain woodstove is 9 decimeters long, 3.75 decimeters wide, and 6.75 decimeters high. What is the volume of this stove? Give your answer in millimeters.

Liter and Milliliter

Page 114

1. A gallon of gas is 3.785 liters. How many milliliters is this?

Metric Units of Mass

Page 115

1. A certain woodstove weighs 148.7 kilograms. How many grams does it weigh?

Relationship Among the Metric Units

Page 116

1. When he is working in his woodlot, Frank carries 3.784 liters of gas-oil mixture with him. What is the weight of this mixture in kilograms?

Careers (Chimney Sweep)

Page 118

1. If a chimney is 5.168 meters long, how many centimeters of rope does a sweep need to reach the entire length of the chimney?
2. Lana's chimney sweeping service keeps her busy. She services a county that is 16.09 kilometers long and 12.87 kilometers wide. What is the area of the county she services?
3. Some of the tile chimneys Lana cleans are rectangular. If a particular chimney is 30.48 centimeters wide on one side, is 25.4 centimeters wide on the other, and is 487.6 centimeters long from top to bottom, what is the volume of this chimney?
4. Sometimes Lana uses a powerful vacuum sweeper to help clean a chimney. Her cleaner moves air at the rate of 25485.3 cubic

decimeters per minute. How many cubic centimeters is this?

Equal Fractions

Page 132

1. A certain piece of tinder measures 10/16 inches in diameter. Reduce 10/16 to its lowest terms.

Mixed Numbers

Page 135

Note: This section is described conceptually here, rather than in terms of specific problems.

Using the ruler pictured below, give the length of each object in inches. Use mixed numbers. The "objects" pictured here would be all of the different screws, bolts, and nails needed for a stove and chimney installation.

Multiplying Fractions

Pages 140-141

A. Mr. Wilson recently purchased some land. He planted 2/3 of it in trees. He planted 3/4 of the planted land in White Oak trees. What fraction of the whole piece of land did he plant in White Oak trees?

B. Debby's garden covers 1/3 of an acre. She sprinkled wood ashes

from her stove as a fertilizer on 1/2 of her garden. What fraction of an acre did she sprinkle wood ash on?

Multiplying Fractions and Whole Numbers

Pages 142-143

1. Mrs. Williams owns a 160 acre farm. She has decided to leave 1/8 of this in timber as a source of wood for her wood burning stove. How many acres did she leave in timber?
2. John lives on a 15 acre "mini farm." Ten acres of this farm are timber. Of the 10 acres, 1/3 is planted in Black Walnut trees, an extremely valuable wood for furniture building. John decides to save the Walnut for sale to lumber mills. How many acres is John saving for sale to the mills?

Multiplying Mixed Numbers

Pages 144-145

1. Phillip has drawn a scale model of his proposed stove installation. On the drawing, his chimney is shown as 6 1/2 inches long. Actually, his chimney is 24 times as long. How long is his chimney?

Dividing by Fractions

Pages 146-147

1. Mr. Wilson has a stack of extra nuts as spare parts for his chain saw. The stack is 6 inches high. Each nut is 1/2 inch thick. How

many nuts does he have?

2. How many nuts would Mr. Wilson have if the nuts were 1/3 of an inch thick?

Dividing by Mixed Numbers

Page 148

1. Tim sells and installs wood burning stoves. He finds he can install 1 1/2 stoves per day. How many installations can he do in 10 1/3 days?
2. Mary helps her family by sharpening the chain saw used to cut their fire wood. She can sharpen 1 4/5 teeth every minute. How many teeth can she sharpen in 8 1/3 minutes?

Using Equations Involving Functions

Pages 150-151

1. Terry weighs 130 pounds. He can carry 1/3 of his weight in wood on a single trip in from the wood pile. How many pounds can he carry in a single trip?
2. Mary can carry 1/3 of her weight in wood on a single trip in from the wood pile. She carries 35 pounds per trip. How much does Mary weigh?
3. The amount of increase of hardwood in U. S. forest per year is about 10 billion cubic feet of wood. If hardwoods account for 2/3 of the entire increase each year, how many total cubic

feet are U. S. forests increasing each year?

Using Formulas Involving Fractions

Pages 152-153

1. A certain wood stove has a top surface area of 480 square inches. The top surface is rectangle, with a length of 30 inches. How wide is the top surface?
2. The Johnsons are thinking about how to install their new wood burning stove. They live in an A-frame type of home. The area of a triangular end wall of their house is 22 1/2 square yards. The base of the triangle is 7 1/2 yards long. How high is the wall?
3. Alberta paid $120 for 3 1/2 30 inch sections of insulated chimney flue. What is the price per 30 inch section?
4. The protective metal floor pad under Ellen's wood stove cost her $50. The pad is 6 1/2 feet square. What was the price per square foot?

Adding Mixed Numbers

Pages 160-161

1. The legs on a wood burning stove are 6 3/8 inches high. The body of the stove is 38 1/8 inches high. What is the total height of the stove?
2. Sally has 8 1/2 inches of ashes in the bottom of the bucket she uses to carry her wood ashes from her stove to her garden.

She has room for another 6 1/3 inches of ashes. How many inches high is her bucket?

3. From the top of his stove to where his insulated flue begins, Don has installed 3 1/2 feet of sheet metal stove pipe. The insulated flue is attached to the top of the stove pipe and runs 7 4/5 feet through the ceiling to a point two feet above the roof. What is the total length of his chimney including the stove pipe and insulated flue?

Subtracting Mixed Numbers

Pages 162-163

1. At the time when it was settled in the mid-1800's, Iowa had 7 million acres of woodlands. By 1954, 2 1/2 million acres of this had been converted to corn and soybeans. How many wooded acres remainded in Iowa in 1954?
2. By 1975, 1 1/2 million acres in Iowa remained in woodland. How many acres of woods were removed between 1954 and 1975?

Equations Involving Fractions

Pages 164-165

1. Martha's wood stove is 38 1/4 inches high. It is 240 1/3 inches from her floor to a point two feet above her roof. How many inches of chimney does she need?

2. If Martha, in problem 1, places her wood stove on a pad 1 1/8 inches high, how many inches of chimney does she need now?
3. The temperature in Phillip's house was 50 3/10 degrees one winter morning. The sun and his wood burning stove increased the temperature in his house to 67 9/10 by noon. How much did the temperature increase?

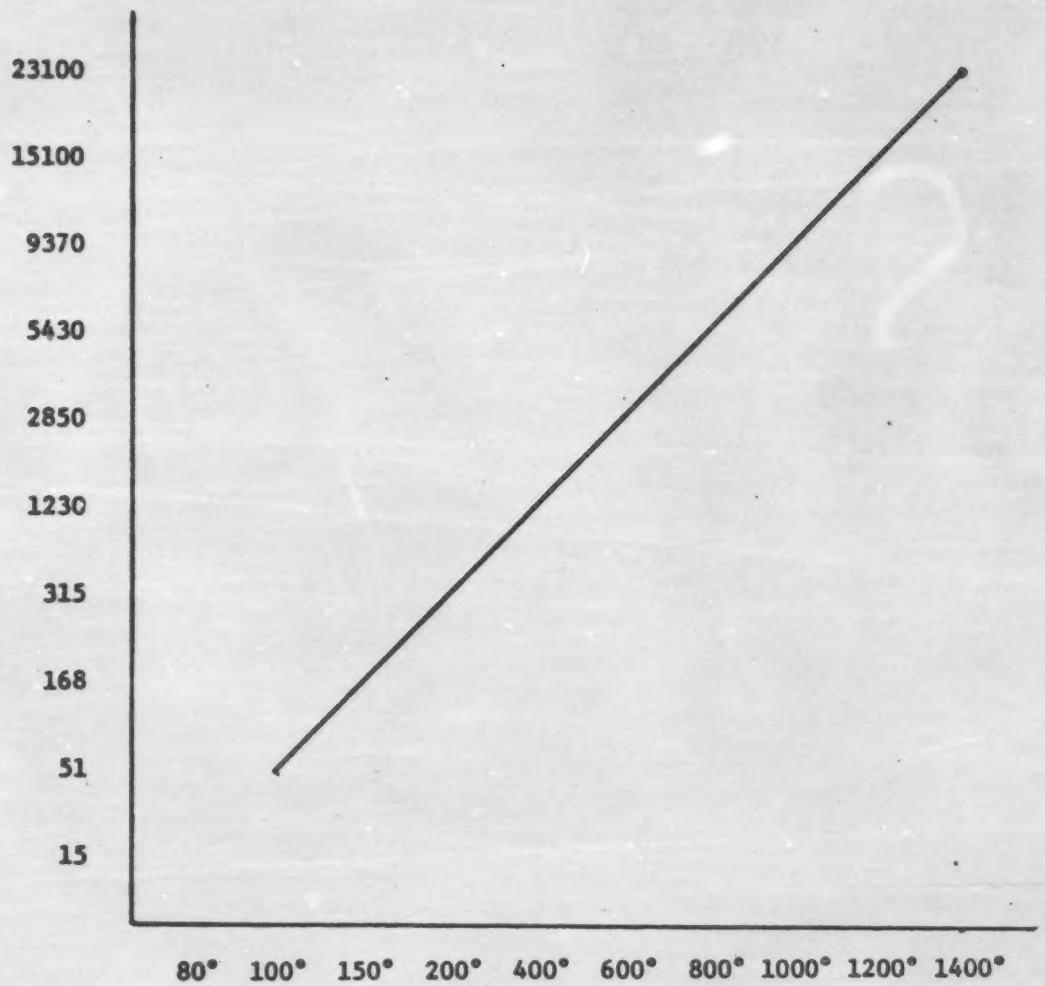
Locating Points for Ordered Pairs and Reading Line Graphs

Pages 168-171

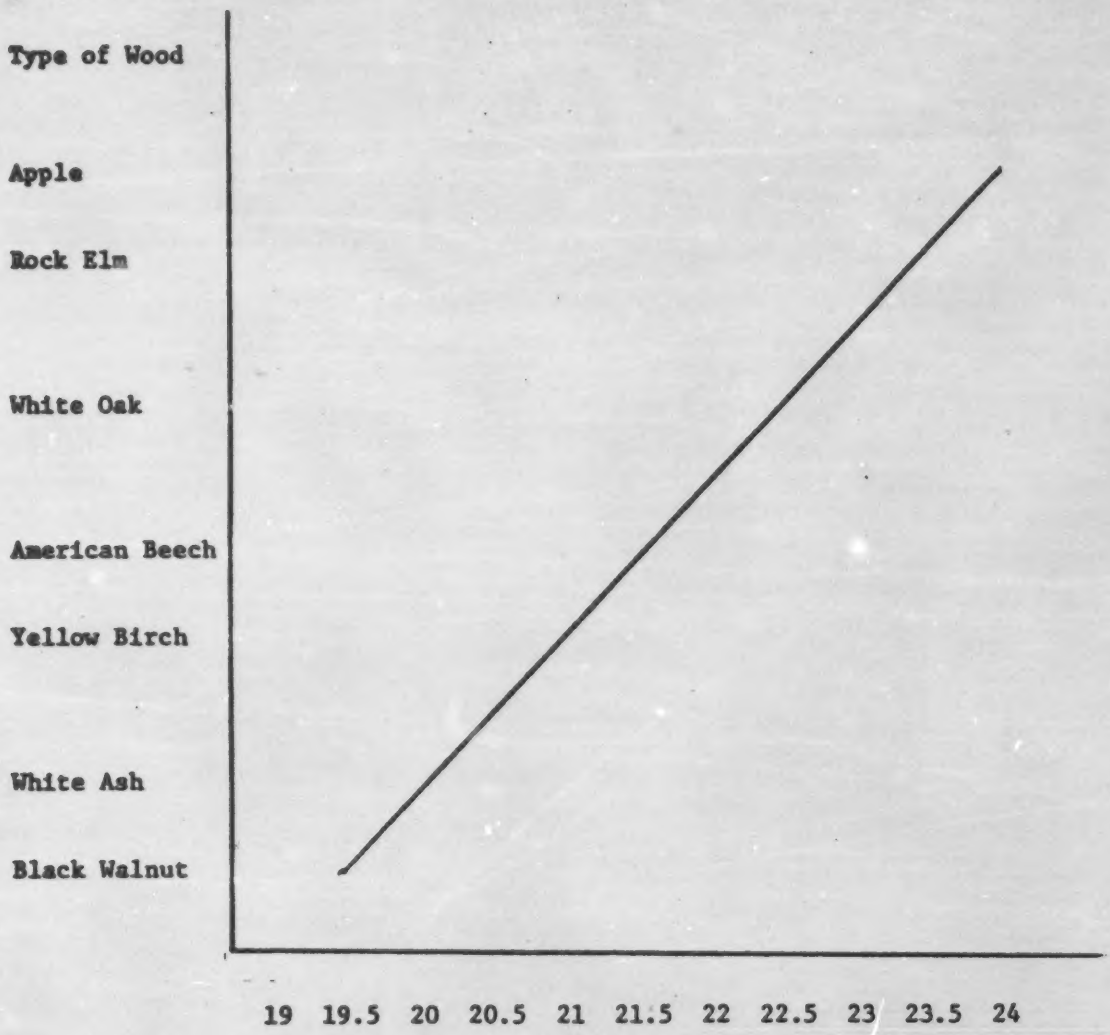
1. Use the graph below. How many BTU's are generated by a stove surface temperature of 600°? Write the ordered pair.
2. How many BTU's are generated by a stove surface temperature of 150°? Write the ordered pair.

Total Energy Transferred

(BTU's Per Hours Per Square Foot)



3. The graph below shows the relationship between the approximate number of BTU's produced by one cord of wood and the type of wood.



1. How many BTU's does a cord of Apple produce? Write this as an ordered pair.
2. How many BUT's does a cord of Yellow Birch produce? Write this as an ordered pair.

Making Line Graphs for Equations

1. The amount of wood supplied by a firewood supplier is related to its price per cord. Use the formula to complete the table.

Cords Supplied ↓ S = 2 Price Per Cord ↓ P

P	S
$ 0	0
50	100
60	___
70	___
80	___
90	___
100	___

2. Make a graph on a grid. Locate points for ordered pairs obtained from your table and connect the points.

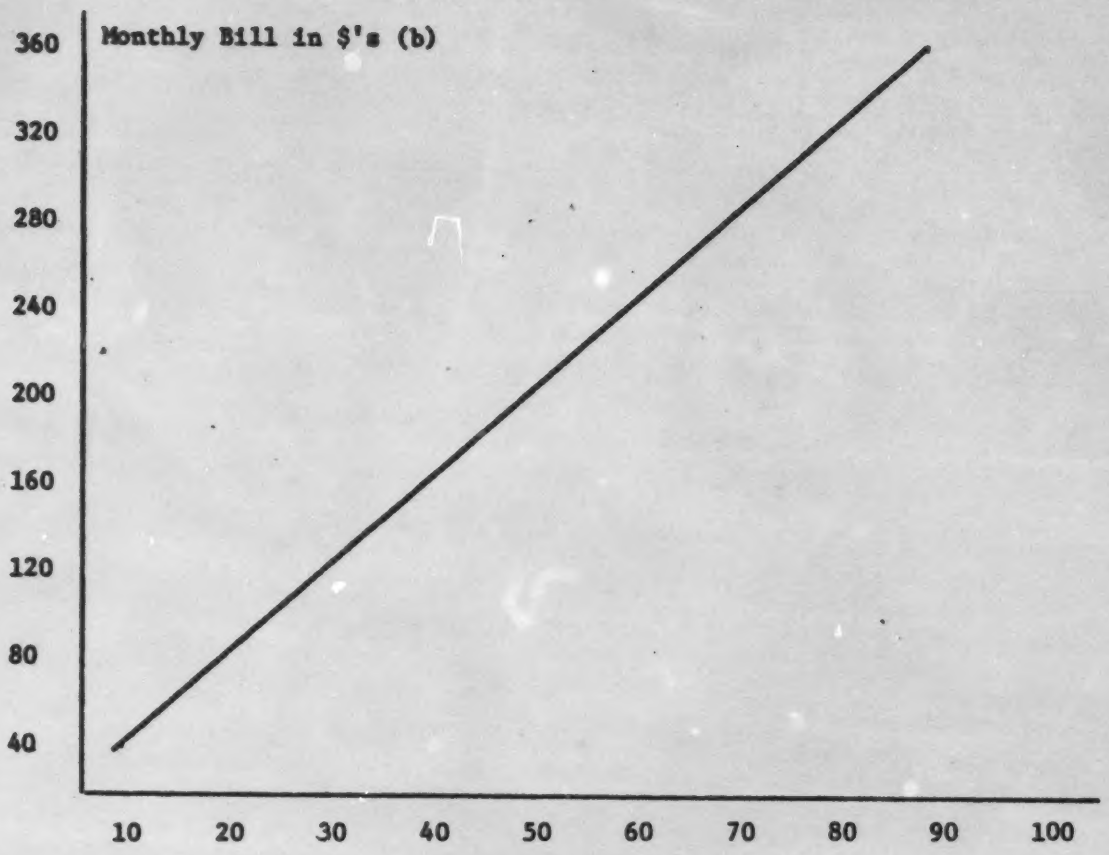
Writing Equations for Tables and Graphs

Pages 176-177

1. The graph shows the relationship between kilowatt hours of electricity used and one person's monthly electric bill. Write the ordered pairs for four points on the graph.

   Which equation fits the data?

   $b = k + 4$ $b = 6k$ $b = 4k$



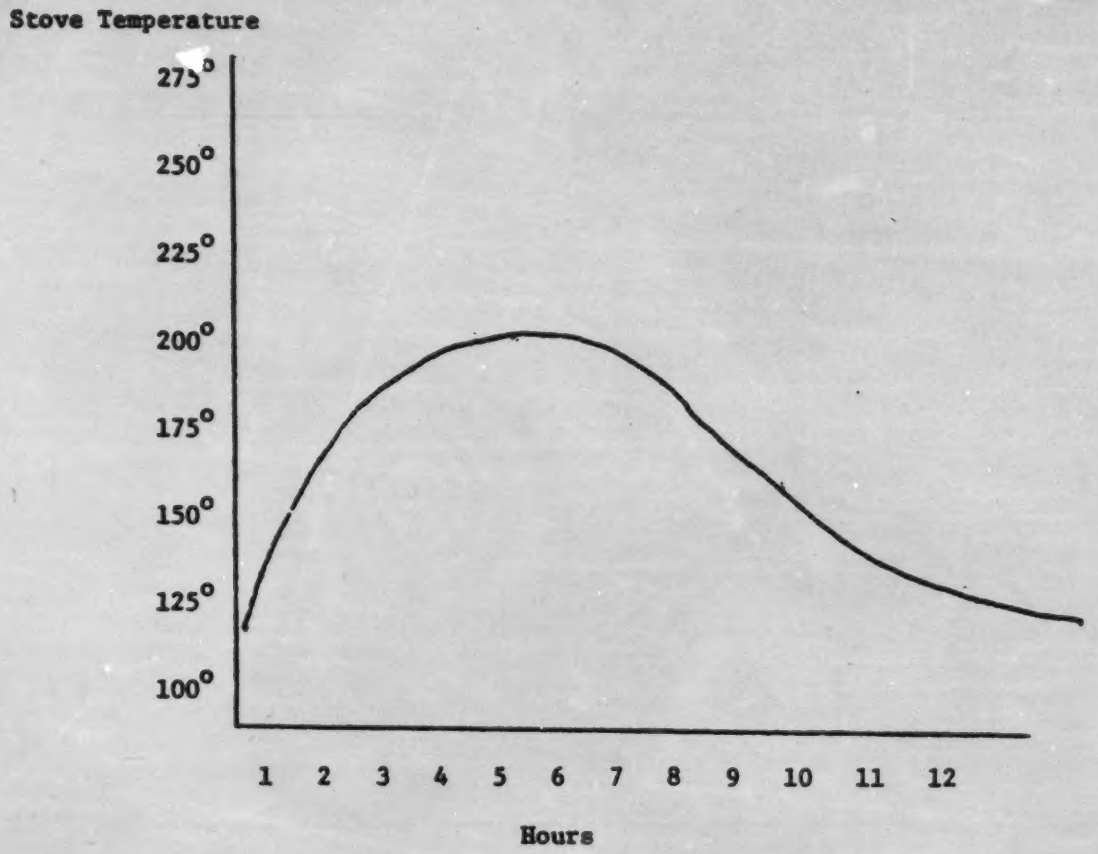
Reading Curved Graphs

Pages 184-185

The graph below shows the relationship between the total "burn" time of a woodburning stove and the surface temperature of the stove.

1. What was the temperature of the stove after seven hours?
2. When was the temperature highest?

3. If it takes a stove temperature of at least 150° to keep you warm on a certain day, how many hours will you be warm?



Areas of Rectangles and Parallelograms

Page 218

1. Frank has installed a sheet of quarter-inch asbestos millboard to protect the wall behind his wood stove. The sheet of millboard is 55 inches by 48 inches. What is its area?
2. The area of the rectangular top of Frank's wood stove is 558 square inches. If the width is 18 inches, what is the length?
3. Don is going to plant trees on a rectangular plot that is 220 yards long and 180 yards wide. How many trees can he plant if he allows 9 square yards per tree?
4. Bob bought a rectangular piece of plastic to cover his wood pile. The piece is fifteen feet long and twelve feet wide. Bob paid 4¢ per square foot. What was the cost of the piece of plastic?

Areas of Trapezoids and Triangles

Page 221

1. Tom has placed a piece of quarter-inch asbestos millboard under his stove to protect the floor. The piece is the shape of a trapezoid. The bases are about 5 feet and 7 feet long. They are about 4 feet apart. What is the approximate area of the millboard?
2. Sandy has decided to place her woodstove in a corner of her living room. She must buy a triangular piece of asbestos millboard to protect the floor. The base is 8 feet and the height is 4 feet. What is the cost if the piece of millboard is $1.25 per square foot?

Surface Area of Polyhedrons

Page 222

1. Sarah wants to paint her stove. To determine how much paint to buy she needs to estimate the total surface area of the stove. Her stove is roughly the shape of a rectangular prism measuring 30 inches by 24 inches by 36 inches. What is the total surface area of the stove in square feet?

Circumference of a Circle

Page 227

1. Wayne plans to make a set of passive heat exchangers that attach to the stove pipe. He needs to know the circumference of the pipe. What is the circumference of a stove pipe that is 6 inches in diameter? What is the circumference of a pipe that is 8 inches in diameter?
2. Susan wants to extend the height of her stove pipe. She needs to know the diameter of the pipe. She does not want to climb up on the roof to measure the diameter. Instead she measures the circumference of the pipe inside the house. The pipe is just under 16 inches in circumference. What is the diameter to the nearest inch?

Area of a Circle

Page 228

The maximum input capacity of a chimney depends on the area of the flue. What is the cross sectional area of a flue that has a radius of 3 inches?

Volume of a Cylinder

Page 230

1. What is the volume of a stove pipe 15 feet long having a radius of three inches?
2. Depending on where he places his wood stove, Steve will either use a 15 foot section of 6 inch diameter stove pipe or 12 foot section of 8 inch diameter pipe. Which stove pipe has the greater volume?
3. George is cutting up a tree trunk for firewood. The log is cylindrical in shape. It is 12 feet long and 16 inches in diameter. How many cubic feet of firewood are contained in the log?

Surface Areas of Cylinders

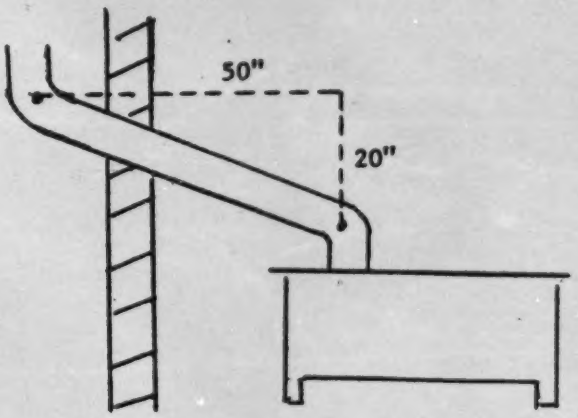
Page 232

Sarah wants to paint her stove pipe. To determine how much paint to buy she must know the surface area of the pipe. The pipe is 4 inches in diameter and 22 feet long. What is the surface area of the pipe in square feet?

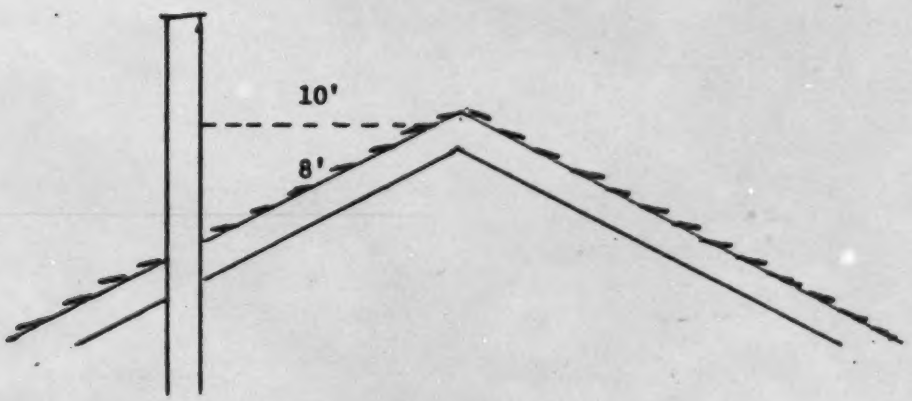
Using the Right-Triangle Relation

Page 247

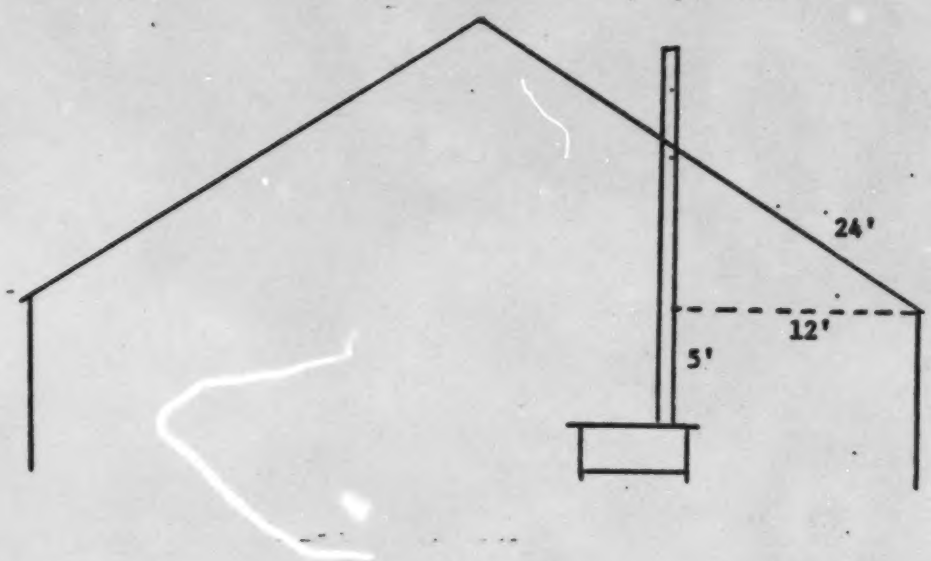
1. Find the length of the straight section of the stove pipe.



2. A wood stove chimney should be at least 2 feet higher than the highest point of the roof within 10 feet. Find the minimum height of the chimney.

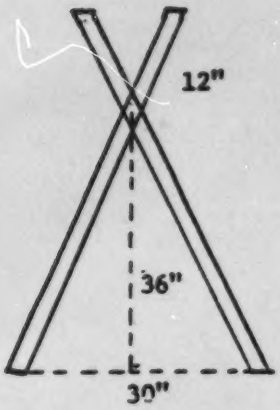


3. Bob is installing a wood stove in an A-frame house. How long is the stove pipe from the stove to the ceiling?



4. If the stove is placed 2 feet closer to the wall, how long is the stove pipe?

5. Ted is going to build a crossbuck for sawing logs. How long are the legs?



Using Proportions

Page 262

1. Don counted 14 dead Elm trees on a 1/2 acre section of his woods. He has 12.5 acres of woods. About how many dead Elm trees are in his woods?
2. Don can cut 1/2 of a cord of wood in 2 hours. At this rate how much wood can he cut in 5 hours?
3. Don can run his chain saw 40 minutes on a full tank of gas. The tank on his chain saw holds 3/4 quart of gas. How long can he run his chain saw if he has 6 quarts of gas on hand?

4. Don burns about 12 lbs. of wood in his stove every 2 1/2 hours. How long will 486 lbs. of wood last him?

Page 268

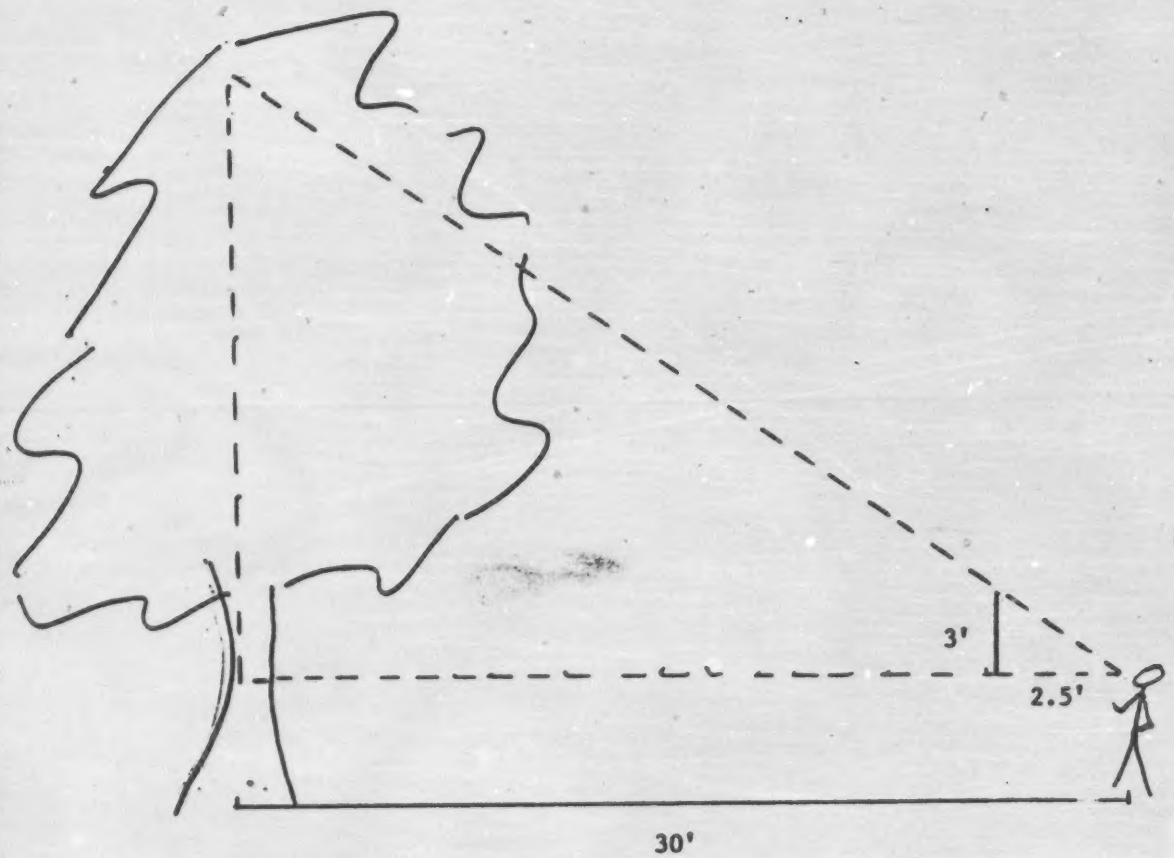
Determine the ratio of length to height for the models of wood stoves listed below.

Model	Length (inches)	Height (inches)
Ashley	30	34
Fisher	32	30 1/4
Jotul	21 1/4	30 1/2
Winnwood	36	28
Vermont	34	32

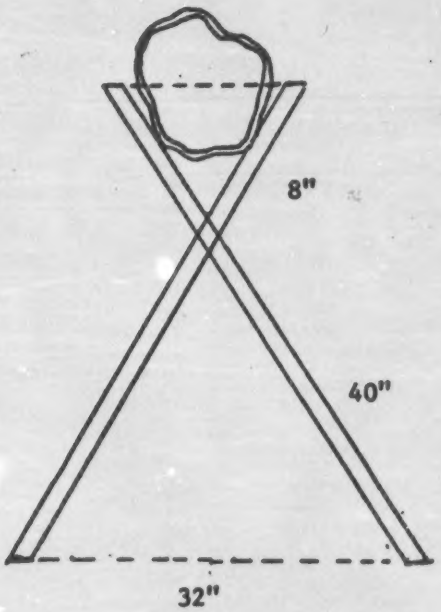
Similar Triangles

Page 270

1. Bob needs to estimate the height of the tree he is cutting down to see if it will clear nearby power lines. What is the approximate height of the tree?



2. George is constructing a crossbuck. The end pieces are made from boards 48 inches long. How large a log (diameter) will his crossbuck hold?



Percents and Fractions

Page 283

1. A cord of Oak contains about 30.8 million BTU's. A wood stove gives off about 15 million BTU's per cord of Oak. What percentage of the heat value of wood is utilized?

$$\frac{c}{100} = \frac{15}{30.8}$$

2. A gallon of fuel oil contains about 140,000 BTU's. The heating effect from one gallon of fuel oil burned in a furnace is 91,000 BTU's. What percentage of the heat value of fuel oil is utilized?

$$\frac{c}{100} = \frac{91,000}{140,000}$$

3. A cubic foot of natural gas has a heat value of about 1000 BTU's. A gas furnace generates about 780 BTU's of heat per cubic foot of gas. What percentage of the heat value of natural gas is utilized?

$$\frac{c}{100} = \frac{780}{1000}$$

Finding Percents

Page 291

1. Bob's wood pile is 3 feet high and 24 feet long. The first 16 feet is Oak. What percent of the wood pile is Oak?
2. Bob paid $64 for his wood. The load of Oak cost $45. What percent of the total cost is the cost of Oak?
3. Bob estimates that his wood pile should last about 45 days. What percent of the wood pile is used after 10 days?
4. A pick-up truck load of wood costs $35 and $5 of that cost is for stacking the wood. The cost of stacking is what percent of the total cost?

Finding a Number When a Percent is Known

Page 292

1. Frank purchased a wood stove and had it installed. The total cost was $1200. The price of the stove was 40% of the total cost. What was the price of the stove?
2. In Frank's neighborhood, 6 of the homes have wood stoves. This is 30% of all homes. How many homes are in the neighborhood?
3. Frank's stove is 75% as wide as it is high. His stove is 24 inches wide. How high is his stove?
4. Frank's stove weighs 280 lbs. This is 87.5% as heavy as his neighbor's stove. How much does his neighbor's stove weigh?

Using Percents

Page 299

1. The fuel value of Elm wood is 21.4 million BTU's per cord. This is about 67% of the fuel value of Hickory. What is the fuel value of Hickory?

   21.4 is 67% of what number?
2. A cord of Elm weighs about 3400 lbs. and a cord of Hickory weighs about 4400 lbs. The weight of a cord of Elm is what percent of the weight of a cord of Hickory?

   3400 is what percent of 4400?

3. A cord of Oak weighs about 3900 lbs. and a cord of Birch weighs about 3400 lbs. The weight of a cord of Oak is what percentage of the weight of a cord of Birch?

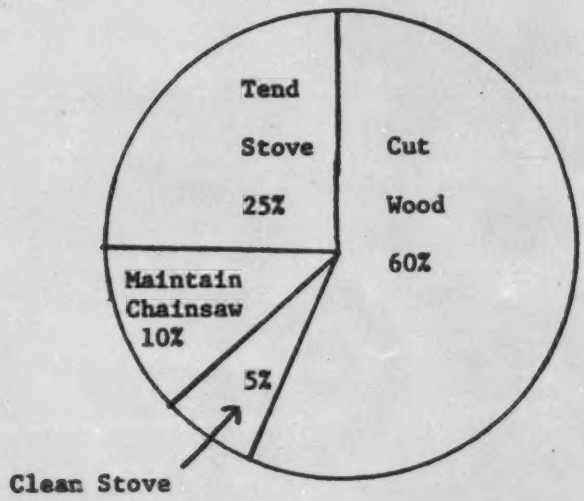
   3900 is what percentage of 3400?

4. About 20% of the weight of seasoned wood is due to moisture. A cord of seasoned Maple contains about 820 lbs. of moisture. What is the total weight of a cord of Maple?

   820 is 20% of what number?

Circle Graphs

Page 302



This circle graph shows how the time is spent by one home owner who heats with a wood stove.

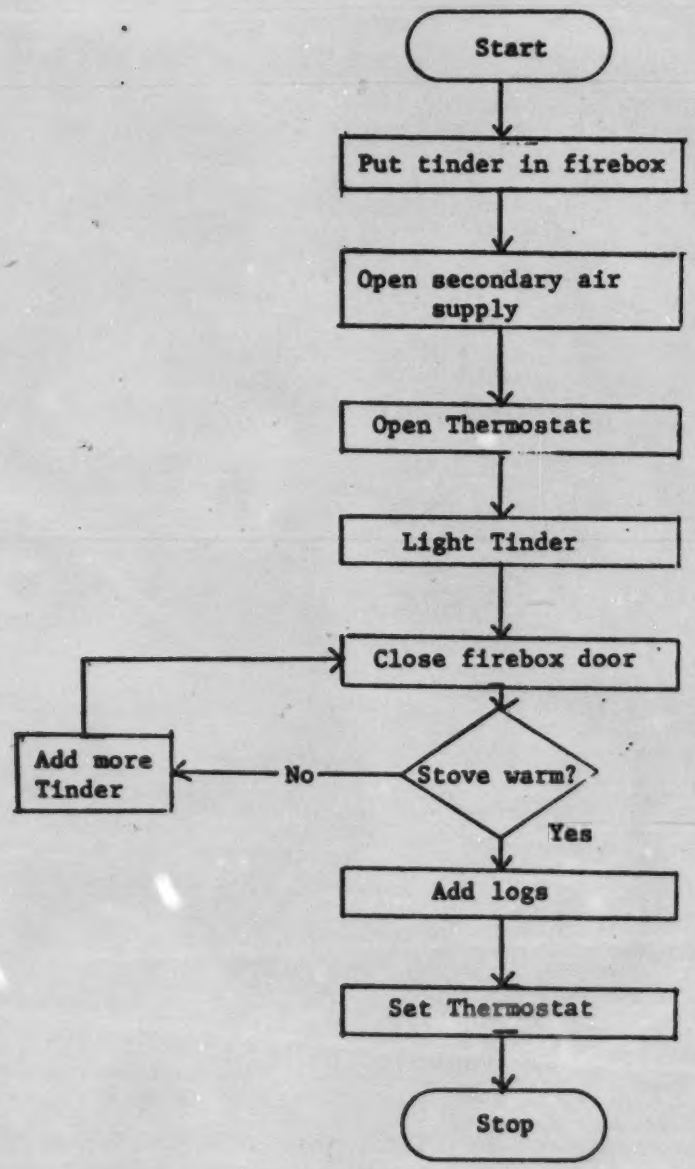
If the home owner spends 450 hours a year in wood stove related activities, how many hours are spent

1. tending the stove?
2. cutting wood?
3. maintaining the chain saw?
4. cleaning the stove?

Flow Charts

Page 308

Here is a flow chart showing how to start a fire in a woodstove.



Counting: Guessing & Estimating

Page 324

Tell whether you would make an exact count or try to make a reasonable estimate if you want to know

1. The number of dead elm trees in a 12 acre wood lot.
2. The number of logs burned in a wood stove in a month.
3. The number of logs burned in a wood stove on a day in January.
4. The number of logs in a cord of wood.
5. The number of hours needed to cut and stack a cord of wood.
6. The number of logs needed to make a wood pile 4 feet high and 10 feet long.
7. The number of pints of gas used by a chain saw in cutting up a cord of wood.

Counting: Tree Diagrams

Page 326

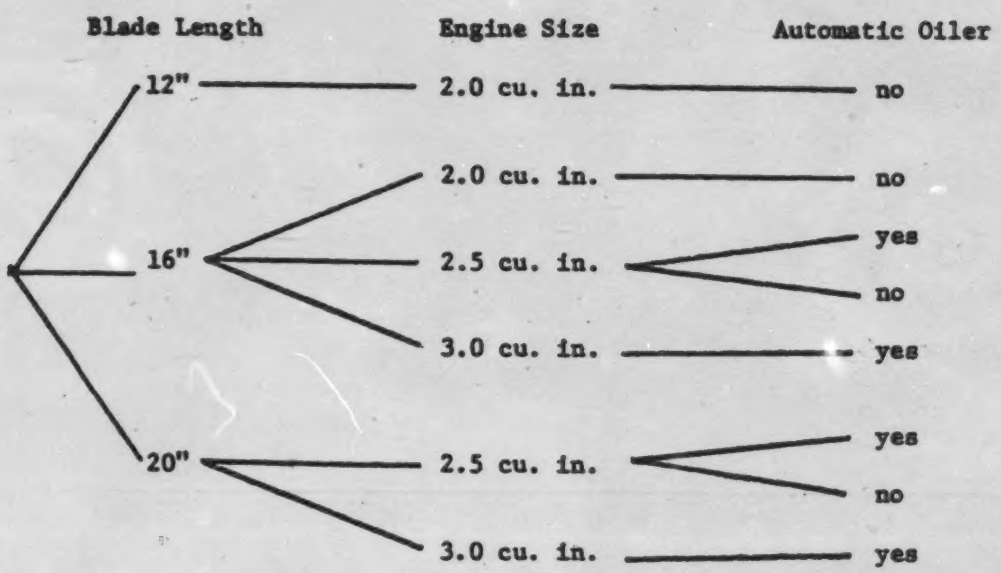
Bob is going to buy a chain saw.

A Sears chain saw has three different blade lengths available: 12", 16", or 20".

There are three different sized engines available: 2.0 cu in., 2.5 cu. in., or 3.0 cu. in. A chain saw with a 20" blade requires an engine with at least 2.5 cu. in. A chain saw with a 12" blade comes with a 2.0 cu. in. engine only. An automatic chain oiler is standard equipment on saws with 3.0 cu. in. engines and is not available on 2.0 cu. in.

engines. An automatic oiler or a manual oiler is available for 2.5 cu. in. engines.

A tree diagram shows how many models of chain saws are available.



Page 327

How many models are available with

1. an automatic chain oiler?
2. a 2.0 cu. in. engine?
3. an automatic oiler & 2.0 cu. in. engine?
4. a 2.5 cu. in. engine & a 3.0 cu. in. engine?
5. an automatic oiler & a 16" blade?

Solve each problem. Use a tree diagram to help you.

6. Suppose an automatic oiler is optional on all models. How many different models will then be available?

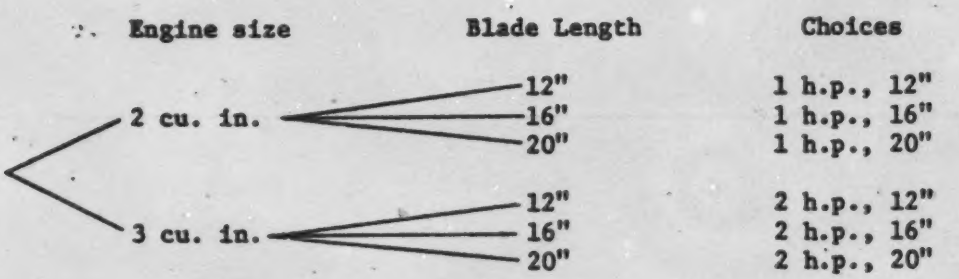
7. If each engine size is available for each blade size, how many models will be available?

The Counting Principle

Page 328

Johnson's Saws stocks chain saws with three different blade lengths and two different engine sizes. How many different models are available?

A. Sally made a tree diagram.



She found that there are six different models.

B. Nancy counted

Number of Engine Sizes		Number of blade lengths		Number of Choices
2	X	3	=	6

She also found that there are six models. Some times it is easier to multiply to find the total number of choices.

Using the Counting Principle

Page 330

Portland Stove Co. has several features available for their stoves. Count the number of different models available using the counting principle.

number of choices for firebox size		number of choices for flue size		number of choices for flue location		number of choices for draft control		number of models
4	x	4	x	3	x	2	=	96

Independent Choices

Page 332

Choices are said to be independent when they have no influence on each other.

Independent choices often occur in repeated trials. Each month Sally orders a load of firewood. She can place her order with one of the 6 suppliers. There are 6 outcomes (choice of suppliers) the first month. How many outcomes are possible the second month? The third month? How many outcomes are possible for two months?

choices for 1st month		choices for 2nd month		possible outcomes for 2 months
6	x	6	=	36

Dependent Choices

Page 334

Choices are said to be dependent because they have some influence on each other.

Each month Susan orders a load of firewood from one of six suppliers. She never places an order with a supplier she has used before. How many different ways could she place orders the first three months?

number of choices for the 1st month		number of choices for the 2nd month		number of choices for the 3rd month		number of possible choices
6	x	5	x	4	=	120

Using Diagrams

Page 338

Mr. Lott collected this data.

There are 32 homes in his neighborhood

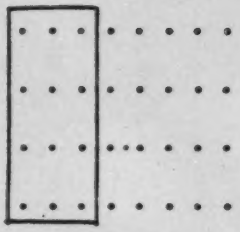
14 have wood stoves

16 have heat pumps

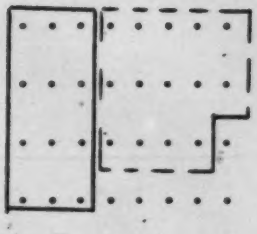
12 have neither a wood stove nor a heat pump.

He asked Barbara and Lillian to find out how many homes have both a wood stove and a heat pump.

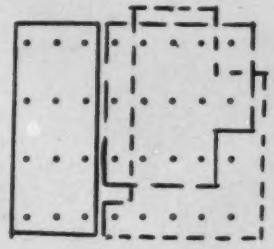
A. Barbara used dots to find the answer. She marked 32 dots to represent the 32 homes.



First she circled 12 dots to represent those homes that do not have a wood stove or a heat pump.



Then she circled 14 of the remaining dots to represent homes with wood stoves.



She then circled 16 dots to represent homes with heat pumps.

The 10 dots inside both dotted circles represents homes with both a wood stove and a heat pump.

B. Lillian computed her answer.

She subtracted to find the number of houses having a wood stove or a heat pump.

Homes in Neighborhood		Homes with neither a wood stove nor a heat pump		Homes with either a wood stove or a heat pump
32	-	12	=	20

She then added to find the number of homes that have a wood stove or a heat pump.

Homes with wood stove		Homes with heat pump		Homes with heat pump or wood stove
14	+	16	=	30

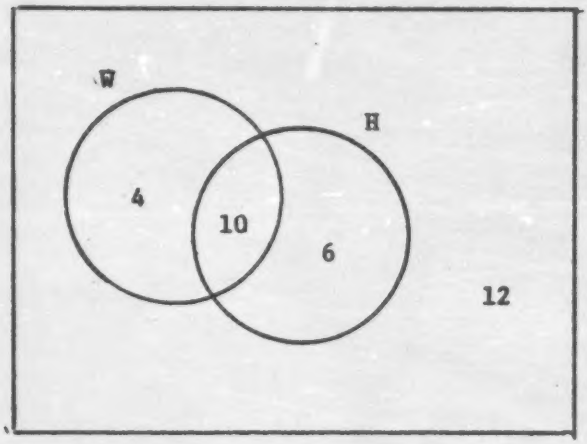
Next she subtracted to find the number of homes that must have both a wood stove and a heat pump.

Homes with wood stove or heat pump		Homes with wood stove or heat pump or both		Homes with both
30	-	20	=	10

There are 10 homes with both a wood stove and a heat pump.

Page 339

C. Mr. Lott made a Venn diagram to show the data.



Circle W shows how many homes have wood stoves.

$$10 + 4 = 14$$

Circle H shows how many homes have heat pumps.

$$10 + 6 = 16$$

The intersection of the two circles (where they overlap) shows how many homes have both a wood stove and a heat pump.

The number 12 outside the circles shows how many homes have neither a wood stove nor a heat pump.

Page 342

Laura has ordered a load of firewood. It will be delivered sometime during the next week.

A. Laura works Monday, Wednesday, and Friday. What are the chances she will be at work when the wood is delivered?

There are seven days and seven outcomes. All are equally likely to occur. There are 3 days out of 7 that Laura will be at work. The probability that Laura will be at work when the wood is delivered is 3/7.

$\frac{3}{7}$ ← Number of favorable outcomes / Number of possible outcomes

B. What are the chances that the wood will be delivered on Saturday or Sunday?

There are 7 possible outcomes. All are equally likely to occur. There are two favorable outcomes. The probability that the wood is delivered on Saturday or Sunday is 2/7.

$\frac{2}{7}$ ← Number of favorable outcomes / Number of possible outcomes

1. What is the probability that the wood will be delivered on a day beginning with the letter T?
2. What is the probability that the wood will be delivered on a day containing the letter T?

Page 344

The local utilities company is going to study the reduction in heating bills in homes using wood stoves. Two such homes will be studied. Of the 34 people who volunteered for the study, 18 have a heat pump in addition to a wood stove.

What is the probability that the two homes selected for the study have heat pumps?

First compute the number of ways to choose the two homes.

Number of choices for the 1st home		Number of choices for the 2nd home		Number of possible outcomes
34	x	33	=	1122

There are 1122 possible outcomes.

Then compute the number of ways to choose the homes with heat pumps.

Number of choices for the 1st home		Number of choices for the 2nd home		Number of favorable outcomes
18	x	17	=	306

Therefore, the probability that both homes selected for the study have heat pumps is 306/1122 or 3/11.

Using Probabilities to Make Predictions

Page 346

Alan wants to estimate the number of days out of the next 30 days that he will burn more than 100 lbs. of wood.

He feels that the chances are 4 out of 7 that he will burn more than 100 lbs. of wood any given day.

He then multiplies to find the expected number of favorable outcomes.

Probability of burning more than 100 lbs.		Number of days		Expected number of days
4/7	x	30	=	17 1/7

Alan estimates that he will burn at least 100 lbs. of wood on about 17 of the next 30 days.

Page 348

Frank sells and delivers firewood. Last year he sold 214 pick-up truck loads. He made a table to show the number of orders for certain types of firewood.

Type of Wood	Oak	Birch	Elm	Hickory	Mixed
Number of Orders	42	28	21	27	96

Use his table to give the probability that an order will be placed for

1. Oak
2. Birch
3. Elm
4. Hickory
5. Mixed

Frank anticipates about 300 orders for wood this year. Give the expected number of orders for

1. Oak
2. Birch
3. Elm
4. Hickory
5. Mixed

Frank has increased his prices for his types of firewood. During the first month after the price increase Frank delivered 32 loads of wood. He again made a table.

Type of Wood	Oak	Birch	Elm	Hickory	Mixed
Number of Orders	5	3	4	3	17

Use his new table to give the probability that an order will be for

1. Oak
2. Birch
3. Elm
4. Mixed

If he received another 300 orders this year, what is the expected number of orders for

1. Oak
2. Birch
3. Elm
4. Mixed

Conditional Probabilities

Page 356

Frank sells wood stoves. He is conducting a survey of his customers by mail to determine annual heating bill savings: About 2/3 of those responding have reported savings of at least $200. Frank has noticed that 8/10 of the homes with heat pumps report savings of over $200.

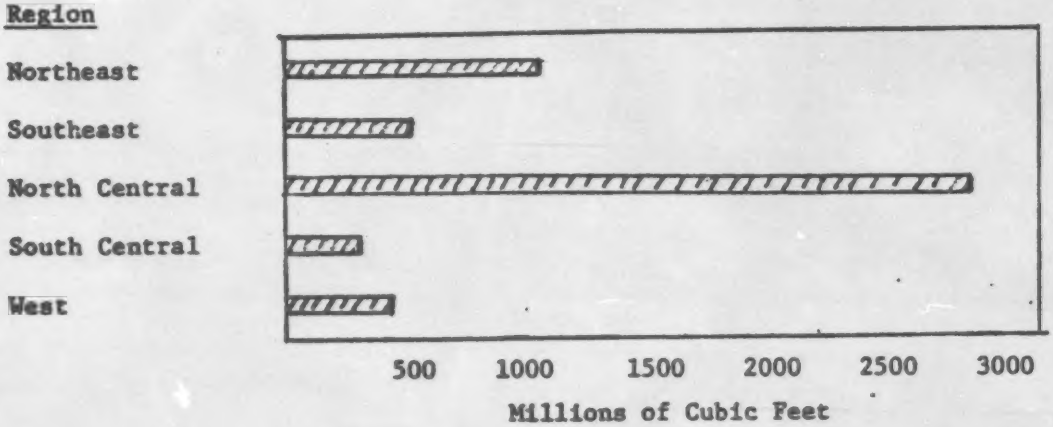
Frank is about to open an envelope containing a response. The probability that it will report savings of at least $200 is 2/3. Frank observes from the return address that the response is from a customer with a heat pump. The probability that the response will report savings over $200 is now 8/10.

Using the additional information, Frank computed a conditional probability. How did he do it?

Picturing Statistical Data

Page 360

Graphs are used to picture statistical data. The graph below shows the net growth in hard woods available per year measured in millions of cubic feet.



1. In what region is there a net growth of about 1100 million cubic feet of hard woods per year?
2. The annual increase in hard woods available in the West is about the same as in what other region?
3. In 1970, there was an estimated net growth of 5300 million cubic feet of hard woods. What percent of the growth occured in the North Central region of the United States?

Sample Statistics

Page 365

In Lakeville, a city with 25,000 homes, a research team interviewed 500 people to find out what types of heating systems they had in their homes.

Heating Systems in Lakeville

Heating system	Percent of sample
Gas Furnace	58
Oil Furnace	18
Electric Heat	19
Fireplace	23
Wood Stove	8
Solar	1
Heat Pumps	12

1. Add the percents. Is the sum greater than 100%? What reasons might there be for this?
2. Estimate how many homes in Lakeville have a gas furnace. (Find 58% of 25,000)

Estimate how many homes in Lakeville have a

3. fireplace.
4. electric heat.
5. wood stove.
6. oil furnace.
7. Of the 500 people interviewed, 22 had a heat pump and a wood stove. What percent was this?
8. Estimate how many homes in Lakeville have a heat pump and a wood stove.

Statistics

Fuel Values of Some Common Woods

Wood	Fuel value/cord (millions of BTU's)
Red Oak	27.3
Shagbark Hickory	30.8
White Oak	30.8
White Ash	25.9
Elm	23.8
Maple	29.7

The Mean

Page 366

1. Compute the mean (average) fuel value per cord for the woods listed.

The Median

Page 367

1. Compute the median fuel value per cord for the woods listed.

Range and Mean Variation

Page 368

1. Compute the range of the fuel values per cord for the woods listed.
2. Compute the mean variation of the fuel value per cord for the woods listed.

Scattergrams and Correlation

Page 372

Which kind of correlation would you expect in scattergrams showing points for these ordered pairs?

1. (outside temperature, cost of heating a home)
2. (weight of wood stove, height of chimney)
3. (moisture content of wood, fuel value of wood)
4. (weight per cord, moisture content of wood)
5. (engine size of chain saw, cost of chain saw)

PROBLEM SET #2

Our purpose here is not to present a reasonably complete problem set, as we did in Problem Set #1. Rather, we want to discuss the importance of qualitative mathematics and the mathematics of uncertainty. As part of this discussion, we provide some sample problems dealing with environmental concepts.

As we mentioned previously, we find it distressing that such meager attention is given to qualitative mathematics and the mathematics of uncertainty in grades K-8 (and beyond). As teachers of applied mathematics in a university, the content of our courses is virtually the exact opposite of the content found in the K-8 mathematics curricula. That is, we tend to emphasize qualitative mathematics and the mathematics of uncertainty.

Our reasons for such an emphasis have very little to do with differences between university-level education and pre-university education. Instead, our approach stems from our experiences as consultants to government and industry, as well as the opportunities we find for applying mathematics in our personal lives. Please understand, we are not denigrating the usefulness of geometry, calculus, the "basic facts," and so on. What we are trying to point out is the importance of currently underemphasized subject matters.

Complexity and uncertainty are the dominant features of an organism's existence, regardless of whether this organism is a person, a government, or a business. Thus, it is vital that humans be equipped

with skills for making sense of complexity and for making decisions under conditions of uncertainty and conflicting objectives.

Qualitative Mathematics

Consider complexity first. The key ingredients in all complex situations are (1) elements, and (2) relations among the elements. Together, elements and the relations among them comprise the structure of a situation. Before any sort of numerical computation can be carried out in a problem-solving effort, it is imperative that one have a sense of the problem situation's structure. It is the structure that guides data acquisition, and it is the data that provide the grist for numerical computation.

In attempting to discern the structure of a situation, one first identifies elements (e.g., factors in the energy crisis) and then relates these to one another in order to produce a structural portrait of the problem situation. This is where the adroit use of qualitative mathematics becomes a virtual necessity.

For example, consider the problem of land use in America, particularly the dilemma of using prime agricultural land for purposes other than farming. This problem situation is becoming acutely important to all Americans, and it certainly should be a crucial topic in environmental education. Some ideas involved in the land use issue appear in the paragraph below.

> The increasing use of marginal land requires a much higher usage of energy and fertilizer. In addition, such land is more susceptible to erosion than is prime land. Buy why must we use this marginal land? The answer seems clear. It is because of the disappearance of good farmland. This is due to pressures from developers and other interests that have caused policy makers to make zoning and other decisions that have resulted in prime farm land being used for parking lots and similar uses. The long-term effect would seem to be food shortages brought about by our decreased ability to produce food from food crops. The result will be, as we might expect, higher food prices for all of us.

While the preceding paragraph may not be the zenith of good writing, it is fairly typical of the sort of thing one hears on television news, reads in newspapers, or hears in casual conversation. It is, furthermore, the type of idea mixture we continually are being asked to evaluate, comment on, and cast votes on. And, note, numbers appear nowhere in this paragraph. In situations like this, training in numerical computation helps only to the extent it has developed general capacities to think and organize.

We contend that no special mechanism exists in the human head that automatically receives such input and presents a clear picture of it to the human being asked to think about it. How, then, does one go about making sense of such issues? One way is to use qualitative mathematics. The questions below will help to illustrate how qualitative mathematics may be used in such situations.

Question 1: Identify the element set, μ, that contains the relevant ideas for making sense of the land-use issues presented in the paragraph.

Answer: μ = [increasing use of marginal land, higher use of energy, higher use of fertilizer, increased susceptibility to erosion, disappearance of prime farmland, pressures from developers and other interests, policies concerning land use, prime farmland converted to nonfarm uses, food shortages, ability to produce food from food crops, higher food prices].

Question #2: Form the Cartesian product of μ with itself.

Answer: The Cartesian product would contain 121 ordered pairs of the form μ x μ = [(increasing use of marginal land, increasing use of marginal land), (increasing use of marginal land, higher use of energy), . . ., (higher food prices, higher food prices)]. The Cartesian product can be more conveniently portrayed in matrix form, as shown below (ignore the 0's and 1's in the matrix for now). Each cell in the matrix represents one ordered pair of the Cartesian product.

Question #3: Use a contextual relation, such as "leads to" and fill in the matrix according to the following rules: place a 1 in the cell if the row element leads to the column element. For example, if food shortages lead to higher food prices, place a 1 in the 9th row, 11th column.

Answer: See matrix.

Matrix of Cartesian Products: Land Use Issue

	Increasing use of Marginal Land	Higher use of Energy	Higher use of Fertilizer	Increased Susceptibility to Erosion	Disappearance of Prime Farmland	Pressures from Developers	Land Use Policies	Prime Land in Nonfarm Uses	Food Shortages	Ability to Produce Food	Higher Food Prices
Increasing use of marginal land	0	1	1	1	0	0	0	0	0	0	0
Higher use of Energy	0	0	0	0	0	0	0	0	0	0	0
Higher use of Fertilizer	0	0	0	0	0	0	0	0	0	0	0
Increased susceptibility to Erosion	0	0	0	0	0	0	0	0	0	0	0
Disappearance of Prime Farmland	1	1	1	1	0	0	0	0	0	1	1
Pressures from Developers	1	1	1	1	1	0	1	1	1	1	1
Land use Policies	1	1	1	1	1	0	0	1	1	1	1
Prime Land in Nonfarm Uses	1	1	1	1	1	0	0	0	1	1	1
Food Shortages	1	1	1	1	0	0	0	0	0	0	1
Ability to Produce Food	1	1	1	1	0	0	0	0	1	0	1
Higher Food Prices	1	1	1	1	0	0	0	0	0	0	0

Question #4: Use your answers in your matrix to construct a structural model of the problem situation.

Answer: See attached structural model.

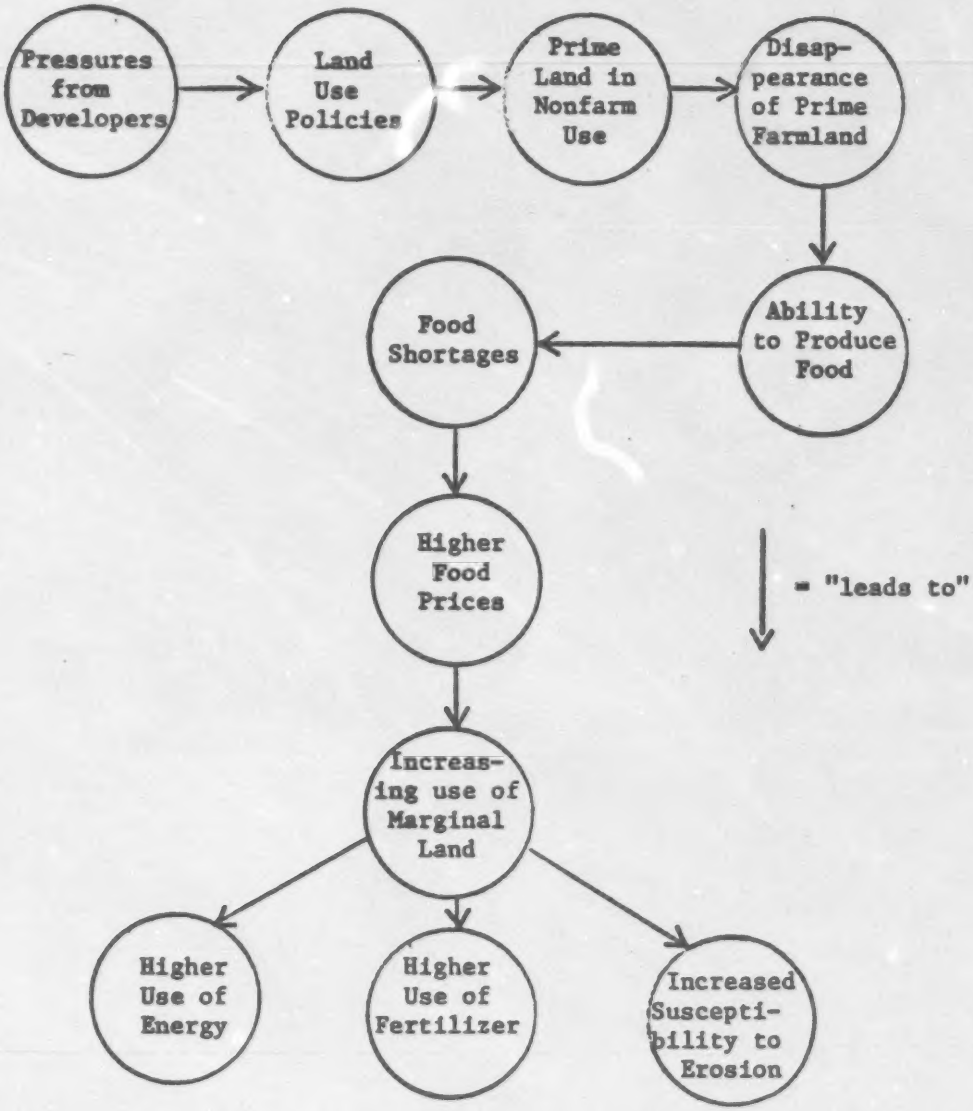
Now, after perusing the questions just presented, the reader may have several quite reasonable objections. Perhaps we can anticipate these.

One such objection might be that these concepts and techniques are beyond the capabilities of K-8 students. But keep in mind that we are not experts in mathematics pedagogy at the K-8 level. We do not claim to be. These problems were written merely to illustrate the kind of thinking needed to deal with unstructured non-numerical situations. The reader can perhaps see that simpler problems illustrating these concepts could be written for virtually any level in the K-8 curriculum.

A second objection might concern the somewhat controversial conclusions that can be drawn from such an exercise i.e., land developers are evil and are responsible for soil erosion and other problems. We would contend that such questions are simply inherent in <u>real</u> environmental problems. That is, delicate issues are not avoidable if one wishes to take environmental education beyond field trips and frog dissection.

In line with this, however, one should note that the structural model of the situation is complete in terms of what was presented in the paragraph from which it was derived, but it is not complete in terms of the real world. That is, a teacher can ask if developers are

Structural Model: Land Use Issue



truly the cause of all this misery. The discussion then turns to the reasons for the developers' desires. The student will quickly see it is not such a simple world after all. Aside from developers' desires for profit, there are other factors that, in turn, are pushing the developers. For example, increases in population and the American dream of owning one's own home escalate the demand for building sites in pleasant areas, which creates the opportunities for development in the first place.

These issues go beyond what normally would be discussed in K-8 mathematics classes. But, the student can retain their structural models for social science class, at which time the socio-economic issues can be discussed. The models can again be taken out in a natural science class to aid in a discussion of soil erosion or energy use, and carried with them on a field trip to observe development activities or to look at evidence of soil erosion. What an exciting world such integration would be for most students!

A third objection that might be raised is the question of teacher preparation to handle such ideas and techniques. We admit this is a bit sticky. We do point out, however, that incredible effort is put into the teacher's manuals that accompany current mathematics texts. A similar effort to aid the teacher in areas of qualitative mathematics should make these concepts manageable to the harried classroom teacher. We turn now to some examples of the mathematics of uncertainty.

The Mathematics of Uncertainty

The mathematics of uncertainty provides a framework for dealing with problems containing unknowns. Decisions made today are often based on projections of what will happen in the future. A good decision maker is not merely lucky, but rather is someone who understands the relationships between the uncertainties of the future and the options available today.

The key to good decision making lies in the ability to structure the problem. Making good decisions requires an understanding of the problem. This in turn requires that the relationships between the elements of the problem be identified.

The mathematics of uncertainty, as a framework for structuring problems with elements of uncertainty, is illustrated in the discussion of the following situation:

> Frank and Mary Simmons are concerned with their ever increasing heating bills. When they built their home six years ago, they had no choice but to use electric heat.
>
> Frank and Mary are considering ways of conserving energy and cutting their heating bills. One possibility is heating with wood. They are trying to decide whether or not to install a wood stove.

The problem appears relatively simple, particularly since it requires a yes or no answer. However, the issue is complex since there are several elements in this problem. (A good decision maker has learned to identify the key elements of the problem.)

Some of these elements can be controlled by Frank and Mary, such as type of wood stove, cost of wood stove and installation and thermostat setting.

However, there are also elements of uncertainty that complicate the problem. In considering heating costs, they must deal with such uncertainties as future increases in the price of electricity, future increases in the cost of firewood and the severity of future winters.

The discussion below will help illustrate how elements of uncertainty can be incorporated into the structure of the problem.

Step 1: Define the problem and identify the goal of the decision maker.

Answer: Frank and Mary want to reduce the size of their heating bills.

Step 2: Define the options (actions) available for solving the problem.

Answer: There are several actions that may be considered. However, to keep the discussion simple, only two actions will be considered:

1) install a wood stove to furnish all or part of their heating needs.

2) do not install a wood stove.

Step 3: Define the elements of uncertainty in the problem that affect the actions being considered.

Answer: Again there are several areas of uncertainty. Some were mentioned in the discussion above. For simplicity, consider only one area of uncertainty: future increases in the price of electricity. Assume that the price will increase at an annual rate of either 10% or 20%.

Step 4: Define the relationships between the options considered and the elements of uncertainty. (These relationships are called consequences. They are the Cartesian product of the set of options with the set of uncertainties.)

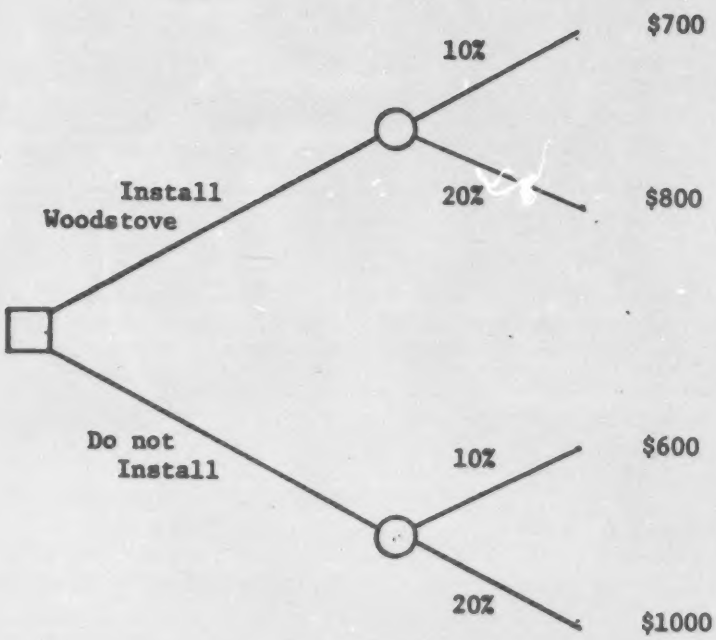
Answer: One way of identifying these consequences is to draw a picture called a tree diagram. A tree diagram is a picture of the structure of the problem. Refer to the diagram below.

Step 5: In order to compare consequences, (and later compare options), assess the value of each consequence.

Answer: In view of the Simmons' goal to reduce their heating bills, it is convenient to evaluate the consequences in terms of heating costs in dollars. For example, if Frank and Mary use a wood stove and the cost of electricity increases at an annual rate of 20%, they might estimate an average heating bill of $800 per heating season. Refer to the tree diagram for the remaining assessments.

The tree diagram pictures the structure of this simplified problem. Viewing the tree from a dollar value point of view, it is obvious that the best consequence is no stove and a low rate of price increases. If Frank and Mary knew for sure what would happen in the future, it would be easy to make a decision. However, they must deal with the

Tree Diagram of the Woodstove Problem



Options

Rate of Price Increase

Dollar Value of Consequences

uncertain rate of price increases of electricity.

Step 6: Assess the value of each option: Compare options by comparing values. Pick the best option.

Answer: The tree diagram indicates that the cost of installing a woodstove should be assessed at between $700 and $800. The cost of the option of not installing should be between $600 and $1000. There are several techniques for making these assessments. Most require a probability assessment for the chances of each of the two rates of price increases.

We have not solved the above woodstove problem in the sense of finding the best option. This was not our goal. The purpose was to demonstrate the importance of the mathematics of uncertainty. The key to making sense of complexity and for making decisions under uncertainty lies in the understanding of the structure of the problem. This requires the identification of the relationships between the elements of the problem. The mathematics of uncertainty provides the framework for constructing the structure and the relationships.

The objections anticipated in the previous section (Qualitative Mathematics) apply here. The responses given in that section are appropriate for this one.

THE STRATEGY

Before a student can begin to handle complex relationships among environmental concepts, the student must first have familiarity with the concepts themselves. That is, in terms of the elements and relations comprising the structure of a situation, the student must understand what the elements mean before the elements can be related to one another. Familiarity with important environmental concepts can easily be developed by repetitive use of these concepts throughout a student's early years of exposure to mathematics curriculums.

In fact, a mathematics series could be designed in such a way that familiarity with environmental concepts gradually emerges simply as a byproduct of using these concepts over and over again in "theme" contexts, much as we did with woodburning stoves in Problem Set #1. By the time a student has progressed through several grades, the familiarity with environmental concepts gained from this approach would allow the introduction and analysis of fairly complex situations involving these concepts. Then these situations could be interrelated with other situations, building in the student's mind an ever larger portrait of his or her environment.

As we have stated before, we believe such a piggybacking of environmental education onto mathematics education to be feasible. Done correctly, with delicacy and intelligence, environmental education can ride on mathematics education with no additional costs incurred by mathematics, or the teaching profession, or public school systems.

CONCLUSION

In the preceding sections of this report we have argued that mathematics education can easily serve as a vehicle for environmental education, and we have presented numerous illustrations of how this might be done. One very basic maxim underlying our proposal is "Never do just one thing." Though such efficiency considerations are important in a busy world, our belief that a marriage between mathematics education and environmental education is appropriate rests on something more than just matters of efficiency.

First of all, there is the fundamental problem of gaining entry for environmental education into already overloaded school systems. If it can be demonstrated that environmental ideas can be piggybacked onto existing subject matters, and we think this is demonstrable, the difficulty of putting environmental education into place in the public school systems will be considerably lessened.

Beyond the question of how to get environmental education into the school systems lies a dilemma central to mathematics education itself. The dilemma is this: Most students are alienated from mathematics. We have only our 20 odd years of teaching mathematics at the university level to offer as evidence in support of this contention; nonetheless, we believe it to be true. The source of this alienation is that students somehow miss the central idea that (among other things) mathematics is a language -- a highly useful language for clarifying and

solving the problems they confront as human beings. Environmental issues are serious, significant, and real. It has been our experience that, when students see the usefulness of mathematics as a language for dealing with the uncertainty and complexity inherent in serious, real, and significant issues, their alienation declines.

Finally, the real excitement in all of this is the promise that environmental education holds for serving as a linchpin that binds together and integrates many subject matters. To speak of a person's environment, the socio-economic as well as the natural environment, is to speak of all that affects the person. A careful synthesis of subject matters using a person's environment as the guiding theme is possible. What a grand and glorious educational experience it would be to see the same concepts approached through literature, mathematics, the visual arts, music, social science, natural science, and so on. It would become apparent to the student that, as someone once said, "to touch a flower is to disturb a star." And, that's what environmental education is all about.

Chapter II

AN EXPLORATION OF THE STUDY OF HUMAN SETTLEMENTS AT THE SECONDARY LEVEL

by

Alexander N. Christakis

Michael E. Davey

Virender Jain

Subcontractor's report under "Development of an Interpretive Structural Model and Strategies for Implementation Based on a Descriptive and Prescriptive Analysis of Resources for Environmental Education/Studies."

August 1979

TABLE OF CONTENTS

		Page
CHAPTER I	THE NATURE OF THE TASK	1
CHAPTER II	A FRAMEWORK FOR THE STUDY OF HUMAN SETTLEMENTS	16
CHAPTER III	TECHNIQUES FOR GROUP DISCUSSION AND INQUIRY	36
CHAPTER IV	THE INQUIRY SYSTEM APPROACH TO THE STUDY OF HUMAN SETTLEMENT PHENOMENA	50
CHAPTER V	A SYSTEMIC ASSESSMENT AND APPLICATION OF THE EKISTICS TYPOLOGY	88

LIST OF TABLES

TABLE III-1	LESSON PLAN FOR MODELING EXERCISE AT THE ECUMENOPOLIS LEVEL	43
TABLE IV-1	EXAMINING UNANTICIPATED CONSEQUENCES OF LAND USE MODIFICATIONS	51
TABLE IV-2	IDENTIFICATION OF PROBLEM ELEMENTS	64
TABLE IV-3	TRENDS WITHOUT ANY POLICY INTERVENTION	67
TABLE IV-4	PROBLEM ELEMENTS INTERFERING WITH ACHIEVEMENT OF GOALS	68
TABLE IV-5	A SET OF METROPOLITAN SETTLEMENT GOALS	74
TABLE IV-6	PROBLEM IDENTIFICATION, A METROPOLITAN PROBLEM SET	78
TABLE IV-7	A PERCEPTION OF URBAN PROBLEM LINKAGES USING THE RELATION "AGGRAVATES": CYCLIC COMPONENTS.	79
TABLE IV-8	ELEMENTS CONTRIBUTING TO PRESENT TRENDS (IDENTIFIED BY SECTOR)	83
TABLE IV-9	REALITY STRUCTURE IDENTIFICATION: CYCLIC COMPONENTS	85
TABLE IV-10	IDENTIFICATION OF POLICY INITIATIVES FOR IMPROVING THE ENVIRONMENTAL QUALITY INDEX OF A METROPOLIS.	86

LIST OF TABLES (cont.)

		Page
TABLE V-1	CONCEPTS EXTRACTED FROM C. A. DOXIADIS' BOOK TITLED "ANTHROPOLIS"	96
TABLE V-2	CONCEPTS EXTRACTED FROM THE STANFORD RESEARCH INSTITUTE REPORT	97
TABLE V-3	ANALYSIS OF PAPERS PUBLISHED IN JOURNAL OF ENVIRONMENTAL EDUCATION	107

LIST OF FIGURES

FIGURE I-1	AN EXAMPLE OF AN OPTIONS PROFILE FOR ENVIRONMENTAL EDUCATION AT THE SECONDARY EDUCATION LEVEL	9
FIGURE I-2	THE SCIENCE/EDUCATION/INNOVATION SYSTEM, VIEWED AS A MULTIECHELON HIERARCHICAL SYSTEM	12
FIGURE II-1	ARCHIVE APPROACH	17
FIGURE II-2	AN ALTERNATIVE APPROACH FOR ENVIRONMENTAL LEARNING	18
FIGURE II-3	A GRAPHIC REPRESENTATION OF THE SYSTEM FOR INQUIRY FOR THE STUDY OF HUMAN SETTLEMENTS .	21
FIGURE II-4	A MODIFIED EKISTIC GRID	27
FIGURE II-5	A FRAMEWORK FOR THE CONCEPTUALIZATION OF ALTERNATIVE SETTLEMENT FUTURES AND THE SELECTION OF A DESIRABLE FUTURE	33
FIGURE III-1	NOMINAL GROUP TECHNIQUE	47
FIGURE IV-1	A PERCEPTION OF LINKAGES AMONG PROBLEMS THROUGH A "CAUSES OR AFFECTS" RELATIONSHIP. .	70
FIGURE IV-2	A PERCEPTION OF LINKAGE AMONG ELEMENTS FOR THE ATTAINMENT OF THE REGIONAL GOAL	72
FIGURE IV-3	A METROPOLITAN GOALS STRUCTURE	76
FIGURE IV-4	A PERCEPTION OF URBAN PROBLEM LINKAGES USING THE RELATION "AGGRAVATES": HIERARCHICAL COMPONENTS	81
FIGURE IV-5	REALITY STRUCTURE IDENTIFICATION: HIERARCHICAL COMPONENTS	84

LIST OF FIGURES (cont.)

		Page
FIGURE V-1	A HIERARCHY FOR EKISTICS	91
FIGURE V-2	HIERARCHY FOR D	94
FIGURE V-3	HIERARCHY FOR A THIRD LEVEL ELEMENT	99
FIGURE V-4	SCHEMATIC OF NORMATIVE MODEL SHOWING SUPERSTRUCTURE	102
FIGURE V-5	STRUCTURE OF LEARNING OUTCOMES FOR ENVIRONMENTAL EDUCATION	103
FIGURE V-6	HIERARCHY FOR THE EDUCATIONAL DOMAIN.	105

APPENDIX

APPENDIX A	SELECTED BIBLIOGRAPHY	A-1

CHAPTER I

THE NATURE OF THE TASK

INTRODUCTION

According to the Environmental Education Act of 1970, "environmental education" means the educational process dealing with man's relationship with his natural and man-made surroundings. The Environmental Education (EE) process has been perceived from the outset as being multifaceted, multi- and interdisciplinary, and issue - or problem-oriented. It should be designed to help the learner both to perceive and understand the concepts of "environment", environmental principles, and to identify and assess alternative solutions to environmental problems.

As a result of inventory and analyses of existing EE programs conducted for the Office of Education by the Arizona State University/ Association of American Geographers in 1975, the following primary recommendation was made:(1)

> *To develop core themes and a conceptual structure in environmental education that synthesizes and integrates pertinent subject matter across and between a variety of traditional disciplines.*

Two supporting recommendations from the same report are listed below because they are particularly relevant to the scope and nature of the task reported here. These are:

Supporting Recommendation 1: Encouragement should be given to those projects that demonstrate an understanding of the interrelationships of local, national, and international issues and problems and their linkages.

Supporting Recommendation 4: Support should be allocated for the development of teacher competency programs to optimize the articulation of core themes.

The Arizona Project selected five core themes as critical to the proper integrated implementation of environmental education:

(1) General Systems Theory

(2) Environmental Unity

(3) Energetics

(4) Economics

(5) Human Settlements.

Following the recommendations of the Arizona Project, the Office of Environmental Education has supported numerous studies that have made contributions in the development of core theme materials for EE.* In particular The Far West Laboratory for Educational Development recently completed a series of Environmental Education Teacher Training Models (EETTM) concentrating on the theme of Energetics, for the secondary level.

One of the major problems faced by educators at all levels with regard to the study of environmental phenomena is the amorphous nature of the subject matter itself. Because of this, and after reviewing and analyzing various studies funded by the Office of Environmental Education (OEE), we

*See Appendix A for a Bibliography showing some of the key documents in this area.

believe that the study of human settlements by means of the Science of Ekistics can contribute to the organization of this complex subject matter.

The intent of our report is to concentrate on the core theme of human settlements in an effort to achieve the following objectives:

- To articulate the importance of human settlement subject matter at the secondary level as one of the core themes of EE.
- To demonstrate the feasibility of developing materials that can be used in the secondary classroom for organizing and understanding problems relating to human settlements.
- To link content materials with process methods in order to build a user-oriented "system of inquiry" relating to the subject of human settlements.
- To integrate in one single document ideas and materials that have been produced by a number of OEE sponsored projects (see Appendix A) so that the EE community will begin to appreciate the role of systemic thinking in the practice of EE.
- To develop a typology for organizing knowledge relevant to EE.

RELEVANT STUDIES

As we have already mentioned, considerable work has already been carried out that is relevant to the subject of human settlements. The Athens Center of Ekistics (ACE) has been doing research on the phenomenology of human settlements for more than twenty years, and has produced numerous

reports on this subject. However, the majority of the ACE work did not have an orientation towards education either in the formal or non-formal sectors.

The California State Department of Education produced in 1973 a publication titled Ekistics - A Guide for the Development of an Interdisciplinary Environmental Education Curriculum.(2) The intent of this publication is to extend the study of conservation and environmental protection beyond the notions of nature study, by helping children understand their interdependence with the natural world and providing them with the knowledge and the skills necessary to understand and solve environmental problems. The State of California's work represents the first attempt to introduce Ekistics into the classroom. However, although the authors of the report acknowledge the work of C.A. Doxiadis, the originator of the science of human settlements, they do not adhere to some of the basic principles of Ekistics, the most important being the role of human agent (anthropos) in the design and utilization of human settlements. This deficiency is very critical from the standpoint of an Ekistics curriculum that will contribute to the appreciation by the high school students of their role in terms of human settlement problem-solving.

The Far West Laboratory Studies

As we mentioned earlier, The Far West Laboratory recently completed a series of teacher training models for the secondary level relevant to the study of urban growth and the quality of life.*

*See Appendix A for a list of the relevant documents.

The Far West Laboratory studies emphasize that the approach to the study of urban growth and the quality of life should be holistic in nature and should focus on:

1. analyzing environmental problems,
2. examining the pro and con arguments of a variety of public and private interest groups, labour, business, and government organizations,
3. exploring possible side effects of various environmental problem solutions,
4. predicting both short term and long term implications of local, state, and national environmental programs,
5. articulating personal goals, desires, and life style needs in terms of their aggregate (regional, national, or global) implications for energy use and resource allocation, and
6. making long term life style decisions which maintain a proper balance between natural system and human system functions.

Such capabilities according to the Far West Laboratories can only be achieved through a curriculum which has the following characteristics:

- Environmental education should be holistic and integrated. Focusing on and clarifying the complex relationships which exist between human system and natural system and examining the components and reciprocal functions of both.
- Environmental education should be transdisciplinary. Utilizing information from a variety of fields including natural sciences, social sciences, and humanities.

- Environmental education should be problem-focused and decision-making oriented.

  Involving learners in real environmental problems or issues which are broad enough in scope to have regional, national, or global significance. It should engage learners in values clarification, problem-solving, planning and decision-making processes which prepare them for dealing with environmental problems affecting both individual life styles and societal goals.

Essentially, Far West believes that the objectives of EE can be achieved through a model of instruction that is based on a general systems approach which can display the many interactions that exist within our natural environment. Further, they wish to develop core themes and a conceptual structure in environmental education that synthesizes and integrates pertinent subject matter across and between a variety of traditional disciplines.

The work completed by The Far West Laboratory in the development of the EETTMs is very systematic and comprehensive. They recognize in their work the important role that learner-oriented tools and strategies can play in the problem-solving and choice-making mode of EE. In their report they indicate the need for process-oriented techniques for the discovery and integration of knowledge relevant to EE. Two such integrative techniques are identified in their report:

1. Information organization frameworks designed to collect, organize, and store information; and
2. Metalanguages which develop a language that can incorporate the elements of various disciplines.

The critical role those techniques can play in the practice of EE has not been fully developed in the context of the EETTM approach.

High School Geography Project

The Association of American Geographers prepared a series of materials for the introduction of the subject of Geography into the classroom. The subject matter is very relevant to the human settlement core theme, so it will be useful to discuss briefly the nature and approach of this project.

Due to the nature of the subject matter, the geography materials were separated into different areas of concentration such as:

1. geography of the cities
2. manufacturing and geography
3. cultural geography
4. political geography
5. habitat and resources
6. a look at the country of Japan

Each of these major areas was presented in separate but small soft-covered books (readers). It would appear that those who designed this approach felt that the students could handle the broad subject area of geography if it were broken down into more manageable components.

Each of the readers contains content materials which relate to the specific area that is under study. For example, the reader which dealt with Habitat and Resources contained content material (background information) which related to that particular area of study. Further, once the initial content material was

presented, a problem was introduced which related to the new material presented and students were asked to discuss and recommend different approaches that could be utilized to solve the problem.

THE RELS IDEA

The idea of a Regional Environmental Learning System (RELS) was first discussed, from a design standpoint, in the Fifth Quarterly Report of the University of Virginia contract.(3) This report presents a basis for the design of a RELS, and attempts to indicate the basis for doing the design as well. One of the most interesting aspects of the RELS design approach is the utilization of the "options profile" technique. We will briefly discuss below the relationship of this approach to the study of the human-settlement-core-theme.

Options Profile Technique

Figure I-1, a modified version of a Figure taken from the Fifth Quarterly Report, shows an example of an options profile for environmental education at the secondary level.* This example appears to be relevant to the introduction of the human settlement theme at the secondary level classroom. The dimensions of the profile that will be emphasized in our current effort are the following:

- o Dimension D: Source of information
- o Dimension G: Learning resources
- o Dimension H: Mediator model

* For a detailed description of the rationale and use of the options profile approach to the practice of EE the reader is referred to [3].

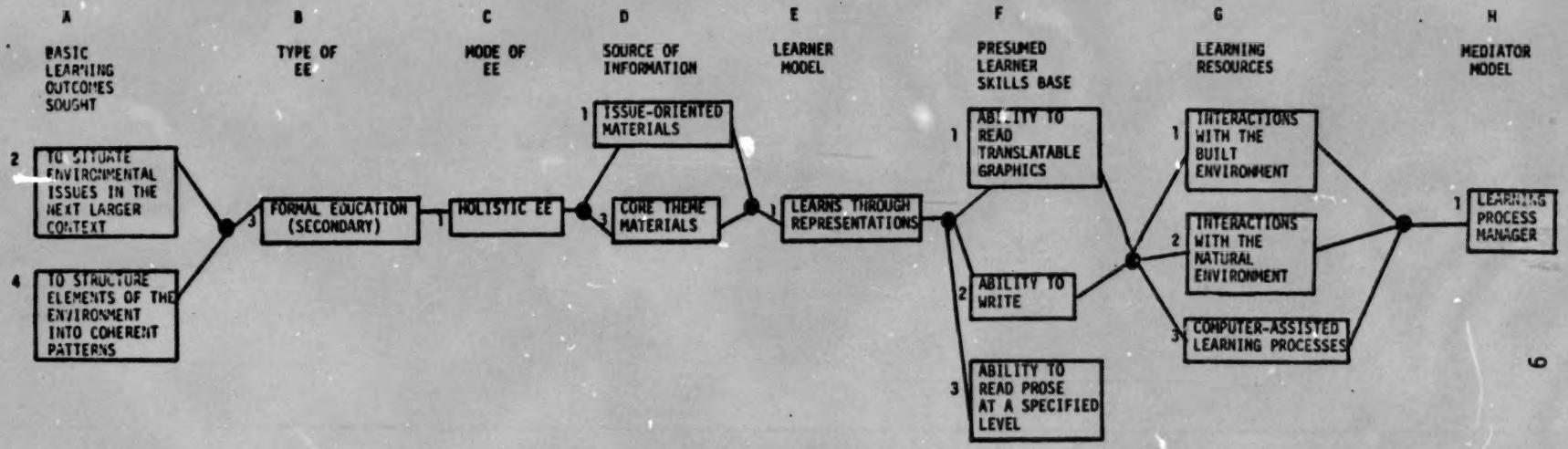


FIGURE I-1: AN EXAMPLE OF AN OPTIONS PROFILE FOR ENVIRONMENTAL EDUCATION AT THE SECONDARY EDUCATION LEVEL.

The usefulness of the options profile approach, as shown in the example of Figure I-1, is that it sets forth the options available to the users in designing a system. The designers/users can make choices along the dimensions of the profile and generate a set of desirable combinations for the practice of EE. It is conceivable, however, that some of the selections might not be implementable because of the existence of certain barriers or constraints. For example, suppose a designer/user wants to introduce at the secondary education level the holistic EE theme of human settlements. Given the complexity of the subject matter it will be exceedingly difficult for the user to implement a profile similar to the one shown in Figure I-1 unless the following two conditions are met:

(1) The user has at his disposal process-oriented methods for group discussion and inquiry. These methods must be made available to the user in a simple and easily comprehensible mode; and

(2) The user must have some materials relating to the content of the science of human settlements in order to engage a group meaningfully and productively in a collective inquiry session.

Two points need to be stressed by means of the discussion of the above example:

The options profile is a very powerful technique in two respects, namely: (a) in terms of identifying interesting and technically feasible combinations in the implementation of a Regional Environmental Learning System (RELS)*; and

* In the context of this discussion the implementation of a RELS is equivalent to the practice of EE as envisioned in the Environmental Education Act.

(b) in terms of identifying important P&D gaps to be addressed through the grants and contracts agenda of the Office of Environmental Education.

TRANSDISCIPLINARY EDUCATION

In his seminal paper on Toward the Inter- and Trans-disciplinary University[4], Erich Jantsch developed an interesting schema for organizing knowledge. The schema is reproduced as Figure I-2.

In accordance with the Jantsch multiechelon hierarchical system, the human settlement core theme belongs at the normative level where the concept of social systems design is introduced. According to this schema the discipline of planning is the appropriate organizing language for the normative level.

In terms of our interest to introduce in the classroom human settlement-oriented thinking by means of the RELS design approach, we can use the Jantsch schema to make the following relevant observations:

(1) The majority of the curriculum materials that have been produced so far fail to recognize the distinctive character of social system design as a result of its belonging to the normative level of the hierarchical system for knowledge organization.

(2) On account of the dominance of the physical sciences paradigm, which according to Figure I-2 belongs to the empirical level, there has been a bias to emphasize this particular level in the production of EE curriculum materials.

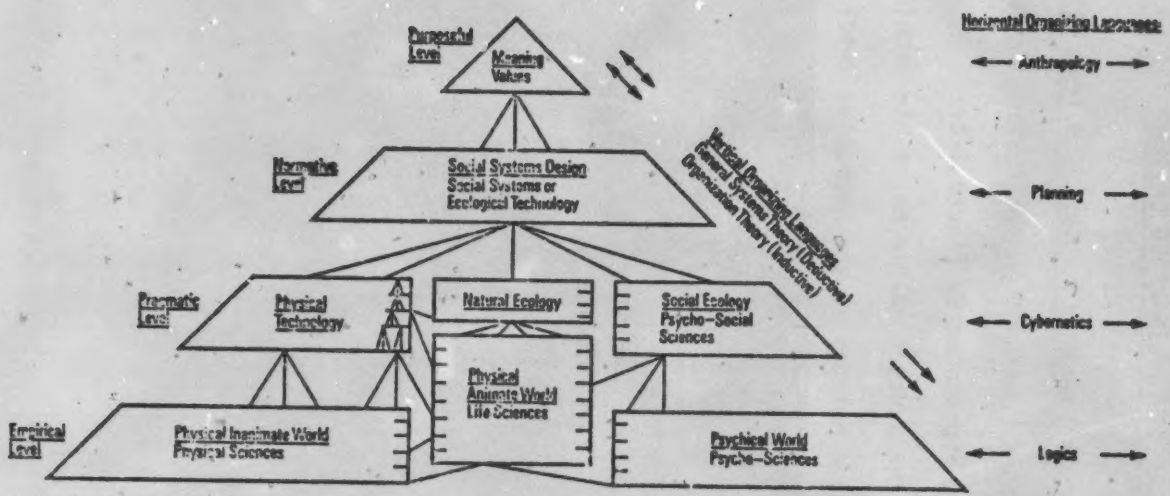


Figure I-2 : *The Science/Education/Innovation System*, viewed as a multiechelon hierarchical system. Branching lines between levels and sublevels indicate possible forms of inter-disiciplinary co-ordination. (From E. Jantsch).

(3) It is very desirable to try to transcend the logical positivist approach when dealing with the social system design level. The utilization of the RELS design approach for EE can do justice to the distinctive character of the normative level of the organization of knowledge schema.

SCOPE OF THIS REPORT

This report is produced primarily in order to link the RELS conceptualization to a particular core theme, namely the study of human settlements at the high school level.

On the basis of our review of existing materials relevant to the study of human settlements we have come to the following conclusions:

(1) Ekistics is a very appropriate subject for integrating and introducing in the classroom the majority of the concepts and materials that have been produced by the EE community to date;

(2) The RELS design concepts are very helpful in identifying desirable outcomes for EE and determining the appropriate combination of options that can lead to the achievement of those outcomes;

(3) The coupling of Ekistics with the concept of the RELS can facilitate the teaching at the high school level of a complex subject matter, such as the study of human settlements.

We believe that the above conclusions are compatible and complementary to the findings and recommendations of the Arizona project, some of which we reviewed previously. Our aim in the following chapters of this report is to lend credibility to our conclusions by means of elaborating on an approach for the productive and meaningful study of the human settlement core theme. The approach and the materials are of an illustrative character and are presented in a format and style which will eventually render them (after elaboration, simplification and field testing) useful to teachers and students at the high school level. We feel, however, the need to field test our recommended approach by exposing it to a group of experienced teachers and/or curriculum developers.

Chapter II of the report sets up the stage for the development of specific applications by explaining our approach for the study of human settlements.

Chapter III discusses two illustrative process-oriented learning tools that have been conceptualized as being integral components of the RELS design.

Chapter IV presents two examples of how some of our overall approach to the study of human settlements can be introduced into the high school classroom.

Chapter V examines the ekistics typology, using a systemic approach, and makes some suggestions for the improvement of the typology. It also proposes a typology for organizing knowledge relevant to Environmental Education and tests the applicability of this typology by analyzing the content of a sample of papers published in the Journal of Environmental Education.

REFERENCES

(1) Environment-Based Environmental Education: Inventory, Analysis, and Recommendations, Arizona State University and Association of American Geographers, June 1975.

(2) Ekistics: A Guide for the Development of an Interdisciplinary Environmental Education Curriculum, California State Department of Education, 1973.

(3) A Conceptual Basis for the Design of a Regional Environmental Learning System (RELS), Fifth Quarterly Report, Contract No. 300-700-4028, January 1979.

(4) Erich Jantsch, Technological Planning and Social Futures, John Wiley & Sons, New York, 1972, pp. 229-241.

CHAPTER II

A FRAMEWORK FOR THE STUDY OF HUMAN SETTLEMENTS

The interdisciplinary cooperation which is widely regarded as fundamental to Environmental Education (EE) is difficult to practice in the classroom not only because of the strong discipline-oriented nature of our school systems, but because the subject matter of EE is not easily "teachable". Too often school systems seem to initiate EE programs which lend themselves to a disciplinary approach. Most environmental education programs tend to emphasize nature and the physical aspects of the ecosystem, i.e., those areas which are most "teachable" along traditional discipline lines, while ignoring man-made environments and the design of social systems such as human settlements.

This chapter examines an approach to the study of human settlements based on the introduction of what we call an "inquiry system". We believe that the study of human settlements can help to eliminate many of the methodological and subject matter problems confronting interdisciplinary environmental education.

PEDAGOGICAL APPROACH

The purpose of any organized instructional environment is to facilitate learning for the intended learner. In such a situation it is usually the teacher, a group of teachers, or a curriculum director who creates the

learning experience for the student. In this case the student usually has limited participation in the learning experience. This type of learning situation is illustrated in Figure II-1 and is referred to as the archive approach.

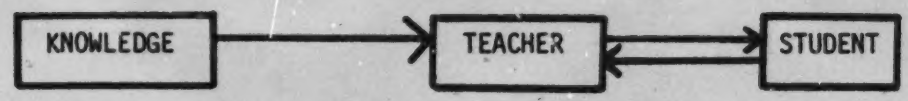


FIGURE II-1. ARCHIVE APPROACH

The above diagram represents a closed approach of instruction where the teacher is the conveyor of knowledge. Underlying this pedagogy is the assumption that the teachers are the archive of knowledge and their job is to pass knowledge on to their students. In return, the students memorize what is conveyed and through examinations the teacher is capable of observing the students expected behavior, i.e., answering questions on a test,thus feeding back what the teacher originally conveyed.

There is another approach of instruction that we feel is more appropriate to the study of social systems. It is an open approach which attempts to take advantage of the resources in the community as well as the ability of the teachers and students to work together in creating a productive learning environment. It can be schematically illustrated by means of the diagram shown in Figure II-2.

With this approach experience feeds knowledge and knowledge feeds experience. As the students gain more knowledge they will be motivated by the catalyst of the unknown to keep open their desire to learn more. In Figure II-2, the teacher acts as a

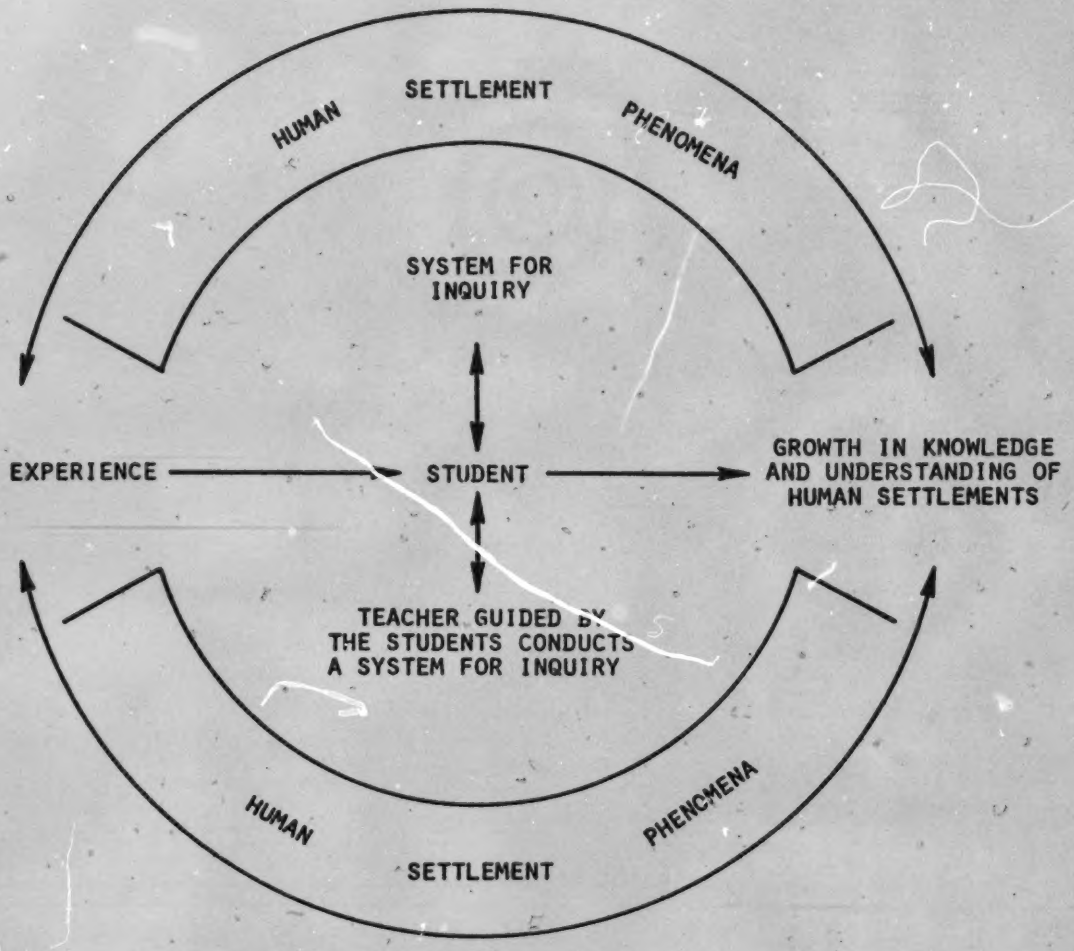


FIGURE II-2. AN ALTERNATIVE APPROACH FOR ENVIRONMENTAL LEARNING

guide and a facilitator for the study of human settlements, instead of the teacher being perceived as the archive of knowledge. Rather, through an open approach to learning the students are guided by the teacher through a "system for inquiry" which gradually leads to a greater understanding and appreciation of a complex set of phenomena.

In such a pedagogical approach students can and should learn in all ways - by the presentation of content material (i.e., background information) by means of books or audio visual equipment, through their own investigation, and by example. Nevertheless, we recognize the key role the teacher must play in this process. Without the teacher playing a central role all the instructional aids would be useless.

Essentially through the study of human settlements we hope to help change the behavior and attitude of students towards environment learning in several ways, such as:

- Recognition that humans are interdependent with their natural environment.
- Appreciation of the importance of a healthy and safe built environment.
- Appreciation of systems thinking.
- Understanding of the need for futures-oriented thinking and research.
- Increased awareness of the holistic nature of the ecosystem.
- Greater ability to understand, organize, and resolve complex problems.

The major objectives of the pedagogical approach of this report are:

- To encourage a change in behavior of the learner.
- To focus learning on the response of the learner.
- To encourage the change of instructional practice.
- To look at the complexity of human settlements by means of an organized system for inquiry.

A SYSTEM FOR INQUIRY

In order to implement the pedagogical approach discussed so far for the study of human settlements, we need a system of inquiry which is holistic, focusing on clarifying the complex relationships which exist between human systems and natural systems, is interdisciplinary, utilizing information from a variety of disciplines, and is focused on identifying problems and opportunities by involving learners in real problems or issues which are broad enough in scope to have local, regional, national, or global significance.

In preparing materials for the study of human settlements in the classroom it is useful to think in terms of the framework shown in Figure II-3. We can identify two distinct domains within our system for inquiry. The inner domain as shown in Figure II-3, is what we call content-specific information. For the study of human settlements the content-specific information should include ideas from : (1) general systems theory, (2) futures research and (3) Ekistics, or the science of human settlements. These

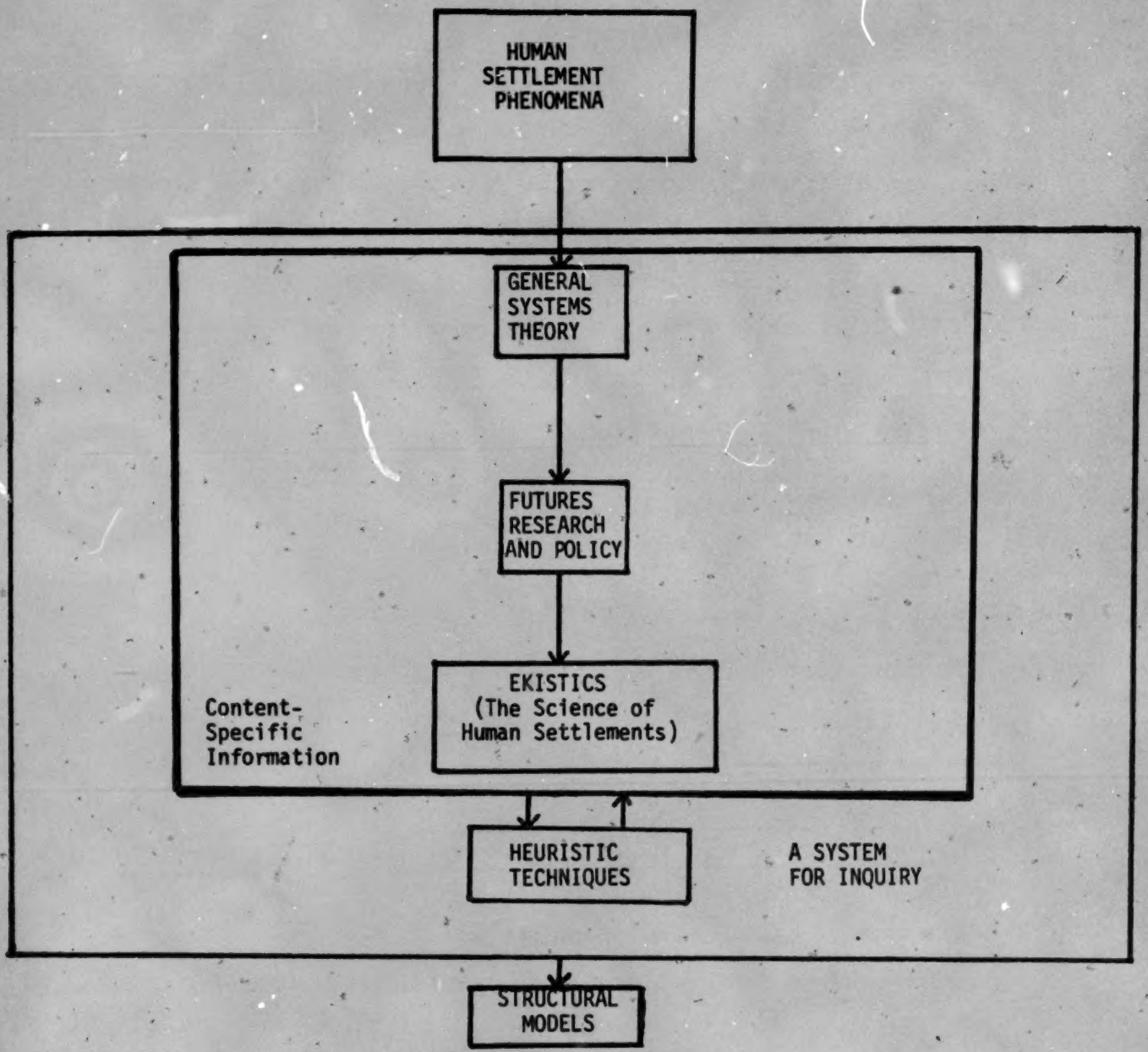


FIGURE II-3: A GRAPHIC REPRESENTATION OF THE SYSTEM FOR INQUIRY FOR THE STUDY OF HUMAN SETTLEMENTS

fields of knowledge will give the high school students the necessary background information which, together with heuristic techniques for exploring complex systems, will allow them to organize the complex phenomena relating to human settlements. The second domain of Figure II-3 displays the role of educational heuristic tools such as Interpretive Structural Modeling (ISM) and Nominal Group Technique (NGT), in deriving models (or representations) displaying their perception of the relationship between different aspects of human settlements. By linking together these two domains, the classroom teacher has at his disposal a "system for inquiry", or a learning system. The class can thus generate structural models that contribute to greater understanding of the complexity of phenomena relating to human habitation.

Recognizing that human settlements are very complex systems we want to stress three things: (1) that in the understanding of the environmental phenomena "systems thinking" is absolutely essential, (2) that system thinking is represented by means of the content-specific information of the framework shown in Figure II-3, and (3) that in order to better understand the complexity of human settlements we have to use educational heuristics technology as represented by such techniques as ISM and NGT.

CONTENT-SPECIFIC INFORMATION

The effective presentation of content-specific information is essential if we are to successfully fulfill the objectives identified in our pedagogical approach to the study of human settlements.

Ekistics

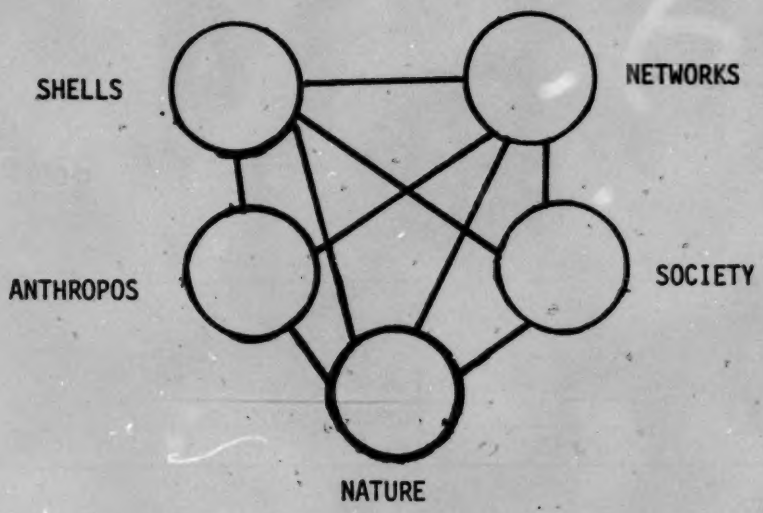
Ekistics is a term invented by an Architect Planner by the name of C.A. Doxiadis, to describe the science of human settlements.(1) Recognizing that the study of human settlements is an interdisciplinary topic involving such disciplines as biology, psychology, economics, sociology, architecture, etc., Doxiadis advanced the notion that a new science was needed for the systematic understanding of phenomena relating to settlements. For example:

- In the U.S. the phenomenon of urbanization has been an ever increasing trend for the last forty years;
- The U.S. was transformed from a country that was 60% rural in 1900 to one that was 70% urban in 1970;
- Large urban areas (megalopolises) experience problems of congestion, pollution, poor quality public services, etc.; and
- Empirical evidence seems to indicate that the public policy mechanisms being used for revitalizing the American cities are not working.

Phenomena like the ones mentioned above prompted the invention of the science of human settlements.

Ekistics organizes all knowledge relevant to human settlements according to five basic elements: Nature, Anthropos (man), Society, Shells, and Networks. These five broad categories, together with a category corresponding to the

synthesis of the five elements, form the basis for understanding, explaining, and predicting human settlement phenomena. The linkages among the five Ekistic elements are graphically represented in the following diagram:



A description of each one of the elements follows:

(1) Nature: This category represents natural resource ecosystems and their structure and behavior. Included here are such things as land resources, air resources, water resources, and plant and animal life.

(2) Anthropos: This category represents humanity, as a system, with an emphasis on those aspects which make up the individual and group image about a setting. This image can be viewed in direct interaction with natural systems on physiological and psychological levels.

(3) Society: This category represents the territorial organization of human settlements based on the daily movements of people. This movement can be viewed in

terms of the interactions of human institutions (economic, political, and social) with natural systems, with an emphasis on the creation of laws and regulations.

(4) Shells: This category represents those structures built by humanity to satisfy the various needs of individuals and society.

(5) Networks: This final category represents those dynamic elements which connect any or all of the above categories, through the movement of energy, materials, and information.

Within each one of the elements, Ekistics assumes the following subcategories.

Nature (Na)

1. Environmental analysis
2. Resource utilization
3. Land use, landscape
4. Recreational areas

Anthropos (M)

1. Physiological needs
2. Safety, security
3. Affection, belonging, esteem
4. Self-realization, knowledge, aesthetics.

Society (S)

1. Public administration, participation, and law
2. Social relations, population trends, cultural patterns
3. Urban systems and urban change
4. Economics

Shell (Sh)

1. Housing
2. Service facilities: hospitals, fire stations, etc.
3. Shops, offices, factories
4. Cultural and educational units

Networks (Ne)

1. Public utility systems: water, power, etc.
2. Transportation systems: road, rail, air
3. Personal and mass communication systems
4. Computer and information technology

Synthesis: Human Settlements (HS)

1. Physical planning
2. Ekistic theory

In addition to the five basic elements, Ekistics introduces an organization of the geographic space by means of twelve communities extending from the scale of the dwelling group to Ecumenopolis, the universal city. The five elements and the twelve communities are graphically represented by means of the modified ekistic grid, as shown in Figure II-4*. At each community scale an assignment has been made of an approximate population size. The population size has been estimated according to the ekistic logarithmic scale which corresponds approximately to powers of seven (7). That in a small neighborhood contains approximately a population of 250, while a Megalopolis, such as the one extending from Boston to Washington, D.C., is estimated to contain 100 million people. These magnitudes are meant to be indicative of the size of the twelve generic type communities assumed in the taxonomy adopted by the science of Ekistics. These 12 entities, or communities, will be shown to be very useful in our attempt to organize and study the complexity of human settlements.

* In Chapter V of this report we analyze the unmodified ekistic grid and relate to the organization of knowledge relevant to Environmental Education.

COMMUNITY SCALE		1	2	3	4	5	6	7	8	9	10	11	12
EKISTIC ENTITIES		DWELLING GROUP	SMALL NEIGHBORHOOD	NEIGHBORHOOD	SMALL TOWN	TOWN	LARGE CITY	METROPOLIS	CONURBATION	MEGALOPOLIS	URBAN REGION	URBANIZED CONTINENT	ECUMENOPOLIS
ELEMENTS	NATURE												
	MAN												
	SOCIETY												
	SHELLS												
	NETWORKS												
SYNTHESIS: HUMAN SETTLEMENTS													
POPULATION T (Thousands) M (Millions)		40	250	1.5T	9T	50T	300T	2M	14M	100M	700M	5.000M	30.000M

Ekistic Logarithmic Scale

FIGURE II-4: A MODIFIED EKISTIC GRID

Futures Research

Another important component of our system of inquiry centers around the concept of time. In view of the fact that most contemporary educators were reared and trained in natural and conceptual worlds which are constantly changing, it is not surprising to find that most high school curriculums are geared more to the past than to the future. Unfortunately, this emphasis on the past has cultivated an educational environment that is mainly concerned with exposing students to outdated concepts rather than teaching students how to imagine alternative futures.

Prior to the 1960's the rate of change in society was very slow. In such an environment it was understandable for teachers to assume that the future would be a simple extension of the past. With a world that was essentially static and experienced very little change, a well developed memory system seemed to be the most important product of a high school education. However, with the shift from local to global perspectives, from a world which was relatively static to one which is dynamic, from independence to interdependence, and from unrestrained growth to restrained growth concerned with the quality of life facing all humankind, the secondary education curriculum can no longer afford to remain "stuck" in the past. Rather, if students are to successfully cope with the problems of tomorrow, schools must initiate courses in the study of alternative futures and encourage futures-oriented thinking. Instead of relying mainly on memory, something a computer can do better, the high school curriculum should be incorporated with a philosophy that accentuates how the past and present <u>will</u> be different from tomorrow.

Today the schools must develop students that are self-propelled, self-directed, flexible and imaginative, capable and prepared to engage in the dynamic, interdependent, and complex world of the future.

To be sure, we are not suggesting that schools stop educating about the past and present. We recognize the importance of how a thorough understanding of the past and present can help to develop a greater sensitivity to tomorrow. Essentially, our intent should be to encourage students and teachers to develop a futures-directed timeframe, through a sharing of their various beliefs and views of what the future may be like.

Systems Theory

General systems theory is essential in the study of human settlements since it can be used for integrating the knowledge from the various disciplines as they relate to the five basic ekistic elements. Systems principles and methods have the distinct advantage of being highly transferable from discipline to discipline. In addition to being transferable horizontally, i.e., between disciplines, they can also be applied vertically, with differing degrees of difficulty, through the various grade levels of schools.

According to the science of ekistics there are two system concepts that are particularly relevant to the study of settlements.

The first principle relates to the observation that human settlements are considered to be complex hierarchical systems. This means that a human settlement is assumed to be composed of many interrelated subsystems each of which is in turn hierarchical in structure. For example, a metropolitan area

like Washington, D.C. is composed of many small towns which in turn are composed of neighborhoods, and so on.

Furthermore, in such systems the whole is more than the sum of the parts in the sense that, given the properties and the laws governing the operation of the parts, it is not a trivial matter to infer the properties or operating laws of the whole. This particular characteristic of human settlements is critical in the practice of the system of inquiry advocated by our approach to social system design and study. There is clearly a lot of knowledge that needs to be discovered by the student through his or her personal and experiential investigation of a specific human settlement and its subsystems.

The second principle is that human settlements are purposeful systems. According to C.A. Doxiadis, the purpose of a settlement is to make its inhabitants safe and to help their human development.

Policy Perspective

Another principal component of the system of inquiry is that of a policy perspective.

There are numerous definitions of policy. All of the definitions basically imply some form of human intervention in the behavior of a system in order to enhance the probability of achieving desirable ends. Since, as we stated previously, human settlements are purposeful systems, the exploration and assessment of alternative policy interventions is obviously very important.

According to H.D. Lasswell, the man who is credited as the inventor of policy sciences, there are three dimensions that need to be considered in a policy-oriented study of human settlements, namely: (a) contextuality, (b) problem-orientation, and (c) diversity of methods.(2)

Contextuality means that the students visualize their choices in the light of a larger social context that goes beyond their individual needs. This dimension basically captures the systemic nature of societal problem-solving. Depending on the problem situation the participants/students will have to explore in a systematic manner various aspects, such as values, intuition, resources, space, and time.

The second dimension that enters the study of human settlements from the policy perspective is the requirement for a problem-orientation. The student must try to deal with the complex nature of interdependent problems by recognizing that: (a) most problems of policy-relevance have ramifications across many disciplines and social sectors, and (b) societal problem identification and resolution demands a sensitivity to the particular cultural situation.

The five important steps involved in the problem-orientation dimension are:

Step 1: Goal clarification: What are the desirable future states of the entity under study? What are the ideals and aspirations of the participants to the social process model?

Step 2: Trend extrapolation: What are the probable future states on the basis of measurable, identifiable trends?

Step 3: Problem identification: To what extent have past and present trends and events approximated the desirable alternative futures spelled out under Step 1? Note that problem(s) are defined as the discrepancies between the desirable futures and the probable futures.

Step 4: Analysis of conditions: What causal factors have conditioned the direction and magnitude of the trends described above?

Step 5: Invention, evaluation, and selection of alternatives: If current policies are continued, what is the probability of goal achievement? What alternative strategies and programs will increase the likelihood for the realization of the desirable futures?

The third dimension of the policy perspective that needs to be built into a curriculum for the study of human settlements is the need for a diversity of methods oriented towards collective inquiry. Depending on the classroom situation and needs, different methods might need to be employed. For example, such methods as ISM and NGT will be described in Chapter III. However, there are other methods such as scenario construction, computer simulation, and the like that can be very useful in the study of human settlements.

Figure II-5 represents an attempt to integrate in one framework some of the main steps of a policy planning situation based on: perception, thought, intuition, values, and feelings. A problem situation, depicted in Figure II-5 as a discrepancy between a "probable future" and a "desirable future", becomes interesting for study only if the difference between these two futures generates a state of dissatisfaction (a feeling) for a student or observer within the context of a particular reality perception. Different observers may, and usually do, perceive a situation differently. The role of perception is to

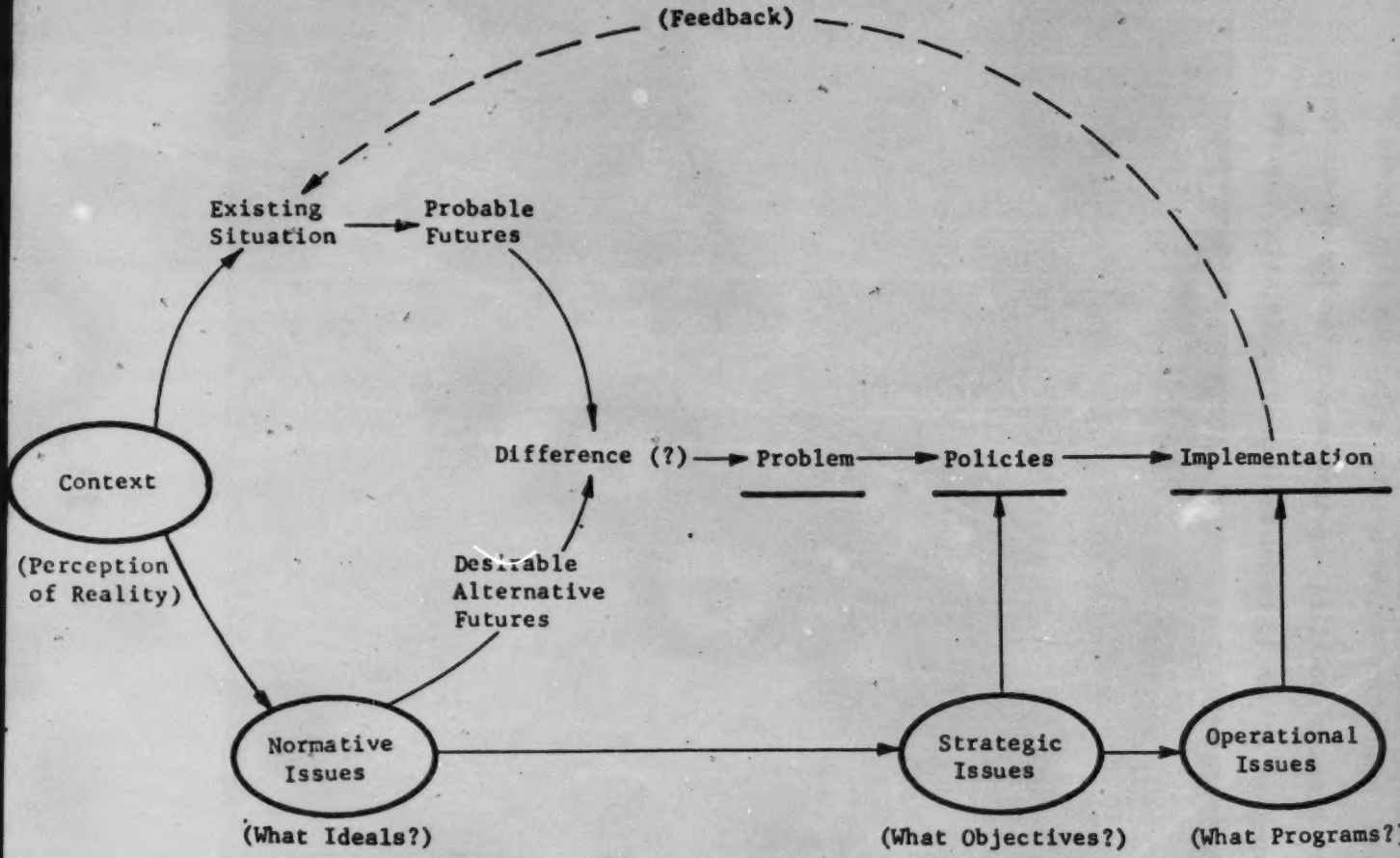


FIGURE II-5: A FRAMEWORK FOR THE CONCEPTUALIZATION OF ALTERNATIVE SETTLEMENT FUTURES AND THE SELECTION OF A DESIRABLE FUTURE

provide the information on which to base the derivation of probable and desirable futures. A solution to the problem situation is a course of action defined by means of policies and instruments for implementation. The selected course of action is based on intuition, thinking over the alternative choices, and preferences (values) about the most desired outcome. Finally, planning and anticipating the consequences of actions, is a continuous process with each choice of action feeding back and generating a new planning situation in a continuous stream.

REFERENCES

(1) C.A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlements, Oxford University Press, New York, 1968.

(2) H.D. Lasswell, A Preview of Policy Sciences, Elsevier, New York, 1971.

CHAPTER III

TECHNIQUES FOR GROUP DISCUSSION AND INQUIRY

In this chapter we will present some of the essential ideas relevant to the use of techniques for collective discussion and inquiry in the classroom for the purpose of teaching the science of human settlements. Before we embark on our discussion of these techniques it is appropriate to consider what we mean by a model and how the techniques can be implemented in the classroom for the construction of models.*

MODELS

A model is an image or a simplified representation of something in the real world. Mental models are formed through our experience, knowledge, and intuition. The formation of models helps us to (a) understand our perceptions about certain things around us, that is, about its parts or features, and (b) our beliefs about how the parts are related.

It is important to realize that a model is a simplified version of something. It does not include all the details about a particular area we might be studying. Rather, it includes those elements or parts that we deem essential for our particular purpose. Therefore, a model makes it easier

*Most of the material dealing with the explanation of the Interpretive Structural Modeling technique has been extracted from Using Computer Modeling in the Classroom to Examine Environmental Issues, University of Dayton, 1978. The purpose of including portions of the University of Dayton effort is to demonstrate the feasibility of developing a comprehensive user-oriented reader for the study of human settlements in the classroom.

to think about and work with complicated situations or in our case a highly interdependent and complex subject matter such as human settlements.

Through the use of models, relatively less important characteristics of a situation or object can be set aside while the teacher and students examine the more vital aspects of their inquiry. Once the initial aspects have been grasped a more complex or realistic model may be developed.

The reason we progress from mental models to models built through words, numbers, or diagrams is that:

- Mental models may be inaccurate or incomplete;
- Mental models may be inconsistent;
- Mental models may contain too many elements, or pieces of information to keep straight; and
- It is difficult for persons to communicate accurately their mental model to other people.

Finally, it is important that we appreciate the difference between quantitative and qualitative models. Sometimes this difference is referred to as the distinction between arithmetic and geometric models. Essentially a quantitative model (arithmetic) is a mathematical model which often uses a computer program or a formula that can use measurements or numerical data as certain variables to make numerical predictions or forecasts for future situations. J.W. Forrester's systems dynamics modeling is a good example of a mathematical model.(1) This method was adopted and used in a Club of Rome project studying population and growth, which was published in a book entitled, The Limits to Growth.(2) This controversial study examined data on world population, growth rates, food supplies, pollution growth, and predicted a

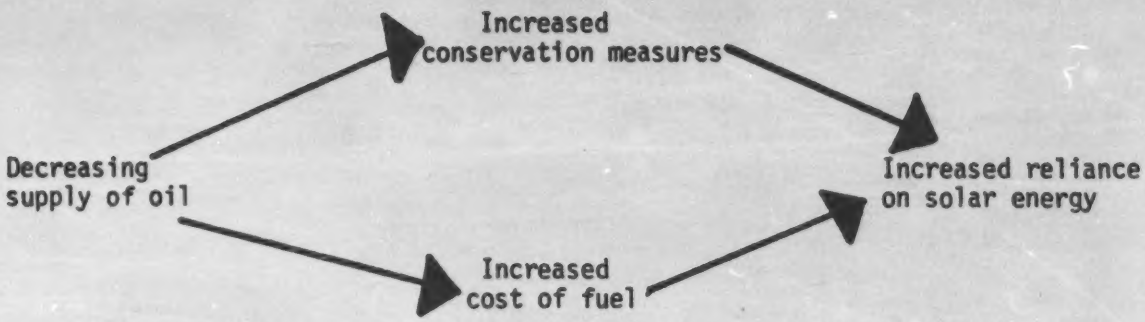
rather darkened picture for the future of mankind within the next 100 years.

However, the computer model used in one of the techniques for inquiry described here does not require quantitative data, and it does not produce a numerical model. It can produce a qualitative (geometric) model that reflects the accuracy of the modelers perceptions, and can be used to describe and interpret a present or future situation.

INTERPRETIVE STRUCTURAL MODELING

The final product of a class exercise conducted with the use of the Interpretive Structural Modeling technique is a geometric model. It graphically represents the views of its creators (in this case, the teacher and the students). It helps to look at the parts of a problem and the way in which those parts are related, and draws a diagram to represent the geometric structure that results from the relationship among the parts. It is an interpretive structural model because it reflects its creator's interpretation of reality. Thus the process by which one creates such a model is called Interpretive Structural Modeling, or ISM for short.

For instance, the students could write out everything they think is a cause or result of the energy crisis, and every way that they think our lives will change as a result of it, and everything the students think should be done about it. If each student were then to draw arrows from one cause to all its effects, a small part might look like this:



where the arrows represent causality, and lo and behold!, they would have created an interpretive structural model without even knowing it.

To create this interpretive structural model of the energy crisis, the students had to rely on the facts at their command and their adolescent understanding of world economics, government intervention, consumer attitudes, etc. The important point here is that through the ISM process, students and teachers are able to share their particular knowledge about a particular subject, while at the same time, they learn from one another.

That is where model building, and in particular Interpretive Structural Modeling, comes into play. When people build a model together, they have a chance to:

- share their ideas
- improve their understanding of the situation being modeled, and
- correct false impressions.

A good model improves our understanding of a situation and helps us communicate that knowledge to others.

Interpretive Structural Modeling can best be utilized when the subject matter or issue under study can be broken down into its component parts. When the class systematically examines how these parts, or "elements" as we will refer to them, are related to one another, then the essential elements of the issue become clearer and the relationships among them are more explicit.

The Use of a Computer

A computer will need to be employed to help the teacher help the class with the process of constructing a model. Computers can be made to do very complex things; however, it is important to recognize that they cannot do anything that a human has not instructed (programmed) them to do.

To help with our discussion let's stick with the energy crisis as an example of how the computer can aid us in our work. If you want your class to study the energy crisis, you might well consider the problem from the standpoint of cause and effect. If the class were then to list all the causes and effects of the energy crisis that they could think of, they would produce what is called an "element list" in the language of Interpretive Structural Modeling. Later on in this chapter we will discuss another technique which is very suitable for generating a list of elements, namely the Nominal Group Technique (NGT).

The next step would be to consider how each of the elements is related to each other element. This is done by selecting a relationship by which to examine them. Since the class is considering causality, the teacher might well choose the relationship (which is always posed as a question): "Does Element A cause Element B?". In our imaginary situation, the symbols A and B might be replaced by the Element 1, decrease supply of oil, and Element 2, increased conservation. The question then would read: "Does decreased supply of oil cause increased conservation?"

The answer to each question must be "yes" or "no", depending on what the class decides by majority vote. All possible pairs of elements are compared

by this method, and this is where the computer comes in. The computer is programmed so that, if an element list and a relationship in the form of a question are fed into it, it will then substitute each possible pair of elements into the question and print the question on paper or on a TV monitor. So the first reason for using the computer is that it writes out each question for you, and saves you from having to put each pair of elements on the blackboard.

The second reason is that the computer reduces the number of questions that the class must answer. For example, if the class decides that "A relates to B" and that "B relates to C", the computer, by a principle known as "inferential logic", has already been programmed to infer that "A relates to C", and it will not ask that question. The manner in which it is programmed to do this is somewhat complex and does not really concern us at this time.

Planning and Conducting an Interpretive Structural Modeling Exercise

Preparing a Lesson Plan

The first significant activity that the teacher must undertake for an ISM exercise is to draw up a lesson plan. Table III-1 shows a sample lesson plan that has been developed by a group of researchers at the University of Dayton in order to be used in a four week high school, (grades 11 and 12) World Problems class. The topic for this lesson was the effects of world population on the global environment, with an overall goal of helping the class to understand the environmental aspects of world population growth.

In terms of the ekistics grid described in Chapter II this lesson plan corresponds to a problem structuring exercise at the level of Ecumenopolis, i.e., the Universal city. Table III-1 is intended to demonstrate how ISM planning may be done. Planning the lesson simply means that the teacher determines:

- what is to be accomplished
- how to achieve it; and
- how to know when one is successful.

The various aspects of Table III-1 are discussed in what follows.

Objectives

Essentially in the objective phase of the ISM exercise the teacher is striving for the students to:

- obtain information on particular aspects of world population
- become familiar with modeling in general
- identify the elements of the problem situation
- examine relationships among the elements
- create a structural model based on that relationship.

This means that the students would move beyond specific knowledge of facts and trends, which should enable them to analyze the elements and the irrelationships between the elements.

Activities

The activities column lists the specific classroom and homework activities that would prepare students for modeling and take them through the exercise. The lesson would end with an examination of the model's implications. This portion of our exercise refers to both physical activities involving the

TABLE III-1: Lesson Plan for Modeling Exercise at the Ecumenopolis Level.

OBJECTIVE	ACTIVITIES	EVALUATION
1. Student will correctly answer X% of questions on knowledge and comprehension of required reading.	Students will be assigned to read articles in Newsweek.	Written test on content of required reading.
2. Student will be able to write a definition of "model" in his own words	Teacher will introduce class to models in general and ISM in particular through a trivial example.	Test question requesting student to write a definition of "model" and to name some examples.
3. Student will be able to answer yes (/Y) or no (/N) to video-screen question.	Students will enter class consensus on terminal, as instructed by computer technician.	Teacher's observation of students at terminal.
4. Given a trivial example, student will draw a digraph without computer assistance.	Class will construct a digraph for the example used in class, using computer output.	Given a simplistic example, similar, but not identical, to that demonstrated in class, the student will draw a digraph illustrating the given relationship.
5. Given a current world problem or current event, student will identify parts (elements) of the whole (problem) for further study.	Discussion of Third World growth and development (initiated and led by the teacher) will give students practice in identifying elements and examining their influence on the problem of growth and the environment.	In answer to a written test question giving a similar but different world problem, student will list in his own words X% of the elements described.
6. Student will recognize a relationship among elements as distinct from the elements themselves	Teacher will guide class in selection of appropriate elements, by discussion of elements in general, examples of various elements that could be used, etc.	Given a contextual explanation of a real or hypothetical problem and a list of possible elements to model, student will select X% of correct (appropriate) elements, rejecting the irrelevant ones.
7. Student will recognize different kinds of relationships among a group of elements.	Teacher will guide class in selecting appropriate relationship, by discussing relationship in general, examples of various relationships that could be used, etc.	Given a contextual explanation of world problem, including two or more relationships among elements, student will pick out X% of the relationships.

TABLE III-1 (continued)

OBJECTIVE	ACTIVITIES	EVALUATION
8. Based on what he knows already and new facts and opinions put forth during class discussion, student will evaluate elements two at a time with respect to a given relationship.	Student will answer yes or no to question posed by computer, and defend his choice when challenged by classmates or teacher.	Student will correctly answer yes or no to X% of questions on test similar to those that the computer would pose.
9. Given individual or group actions in one country, student will identify potential environmental consequences outside of that country.	During ISM modeling session, students will discuss such topics. If they do not arise spontaneously as a result of computer-prompted questions, teacher will interject them as appropriate.	Student will correctly answer X% of written test questions on local activities and their global effects.
10. Given a model such as those developed and discussed in class, student will pick out key elements and discuss possible courses of action.	At completion of ISM session when class has structured model, teacher will lead discussion regarding the relative importance of the elements, and class will determine one or more possible courses of action.	In answer to a written test question giving an Interpretive Structural Model, student will select X% of key elements for implementing change and defend those chosen.

computer and its output, and the type of discussion that should occur during this phase. As the teacher is able to adapt the ISM exercise to fit the classroom needs, he/she will develop variations of these activities. However, the procedure to be followed in conducting the ISM exercise remains fairly constant: research, specifying elements and a relationship, structuring the model, and examining the results.

Evaluation

The third column in our lesson plan format refers to the evaluation procedures the teacher should follow to determine whether the objectives had been achieved. For each objective, we have specified how the evaluation was to be conducted, e.g., written test, observation, or type of question.

NOMINAL GROUP TECHNIQUE

The Nominal Group Technique can be used in a classroom setting for the purpose of generating ideas relevant to a particular problem or issue. The technique is particularly helpful in identifying problems, establishing priorities, and exploring actions to be taken for resolving problems. It works particularly well in small group meetings, usually involving up to ten participants and in situations where there is uncertainty concerning the nature of a problem. In these situations it is very desirable to generate ideas from many different points of view and to try, through a systematic process, to neutralize the effect of certain participants dominating the group discussion.

The principal results of the application of the NGT process in a classroom setting will be:

- A list of ideas relevant to a problem situation;
- A more thorough understanding of the ideas generated by the group through discussion and clarification;
- A preliminary prioritization of these ideas according to a specific relation; and
- An opportunity for each member of the class to relate to the group generation of ideas and to feel as being part of the output.

Application of Technique

The first requirement for applying the techniques is that the group must recognize the need to generate a set of items, or ideas, concerning a particular issue or problem. The teacher should act as group leader and must make sure that the ideas are generated according to the specifications of the technique. The major process requirements are:

- Silent generation of ideas in writing by individuals in response to a carefully prepared trigger question.
- Round-robin recording of ideas in which individuals present one idea at a time.
- Serial discussion of the resulting list of ideas for clarification.
- Voting on the priority of generated ideas.

A diagram depicting the various steps of the process is shown in Figure III-1. The diagram depicts the sequence of operations from the initial statement of the issue or problem to the final list of the prioritized set of ideas.

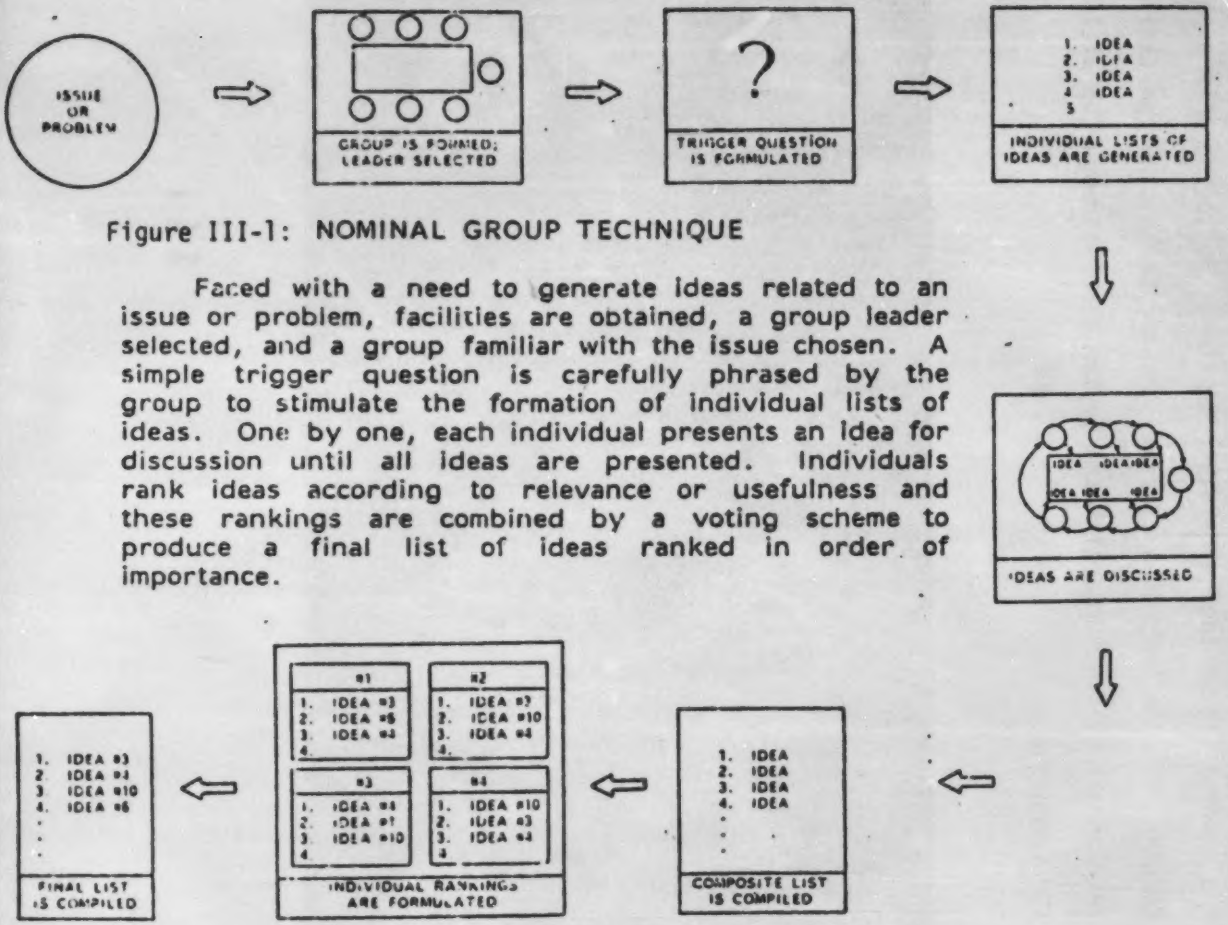


Figure III-1: NOMINAL GROUP TECHNIQUE

Faced with a need to generate ideas related to an issue or problem, facilities are obtained, a group leader selected, and a group familiar with the issue chosen. A simple trigger question is carefully phrased by the group to stimulate the formation of individual lists of ideas. One by one, each individual presents an idea for discussion until all ideas are presented. Individuals rank ideas according to relevance or usefulness and these rankings are combined by a voting scheme to produce a final list of ideas ranked in order of importance.

As mentioned in the previous section the Nominal Group Technique can be used in the classroom together with ISM primarily for the purpose of engaging the students in an idea generation session. Following this session, the teacher with the help of a trained computer technician can facilitate the development of a structural model by the class through the utilization of the ISM technique.

REFERENCES

(1) Forrester, Jay W., Principles of Systems, Cambridge, Mass.: Wright-Allen Press, Inc., 1962.

(2) Meadows, Donella H., and Dennis L., et. al., Limits to Growth, New York: Signet Books, 1972.

CHAPTER IV

THE INQUIRY SYSTEM APPROACH TO THE STUDY OF HUMAN SETTLEMENT PHENOMENA

In this chapter we will present two cases of how the learning system we have discussed can be introduced into the high school classroom. Our first case will demonstrate how the teacher and students could initiate their first exposure to an application of the policy perspective for land use planning at the regional level. The second case will demonstrate how the teacher and students can study a problem situation at the level of a large metropolitan area like Washington, D.C., or Cleveland, Ohio.

These two cases are being presented not because they shed great light on the complexity surrounding the study of human settlements, but primarily because they will illuminate how the learning system approach we have presented is applicable to the present high school curriculum.

CASE ONE: THE EGYPTIAN DELTA REGION

Before any significant activities could take place in the classroom, the teacher or team of teachers would draw up a lesson plan for the implementation of the policy perspective process. The lesson plan (see Table IV-1) is divided into lesson objectives, activities for students to undertake, and ways to evaluate the different activities that take place in the classroom. The overall objective of this particular lesson plan is to demonstrate how modification of land-use patterns can lead to unanticipated environmental problems.

TABLE IV-1: EXAMINING UNANTICIPATED CONSEQUENCES OF LAND USE MODIFICATIONS

OBJECTIVE	ACTIVITY	EVALUATION
1. Students will become familiar with land use problems in the Delta region of Egypt.	Read p. 13-17 article entitled Two Rivers.	Individual presentations reviewing perceptions of land use problems.
2. Students will determine what human settlement element is under study.	Review 5 major ekistic elements.	Groups discuss what primary ekistic elements are being examined, and why.
3. Students will determine the appropriate "community scale" being investigated.	Review modified Ekistic Grid.	Each group selects the ekistic entity they feel is most appropriate for study.
4. Students will develop a list of problem elements contributing to the decline of agricultural production.	NGT led by teacher to help groups identify important elements contributing to the problem situation.	Given reading materials similar to Two Rivers, students will generate the important elements of the problem situation.
5a. Students will understand the dimensions of policy science and begin the 5 step problem-orientation process.	Review materials which introduce the various dimensions of policy sciences.	Groups will present their interpretation of policy dimensions and be able to list the 5 steps of problem-orientation.
5b. Goal clarification.	Based on the list of problems, or the student's perception of reality, each group will list desirable futures for entity under study.	Teacher will discuss with each group why they selected their particular list of goals.
5c. Trend extrapolation.	Each group will extrapolate potential economic, social, and political trend 10 to 20 years into the future.	Instructor could present a similar case to determine if the students have learned how to extrapolate trends for this case.

TABLE IV-1: EXAMINATING UNANTICIPATED CONSEQUENCES OF LAND USE MODIFICATIONS (Continued)

OBJECTIVE	ACTIVITY	EVALUATION
5d. Problem identification.	Each group will review problem list and develop a refined list of problems which are inhibiting the achievement of goals.	The teacher will ask each group to defend the refined list of problems they have developed.
5e. Analysis of conditions.	Each group will use their refined list of problems to construct an ISM of a relationship between elements.	The teacher will evaluate the ISMs produced by the various groups.
5f. Invention, evaluation, and selection of alternatives.	Each group would initiate policy recommendations for achieving goals developed in Objective 5b.	Teacher-led class discussion will evaluate each group's policy recommendations.

In the following discussion we will elaborate on the objectives and activities identified in Table IV-1.

Objective 1: Become Familiar With Land-Use Patterns

Each student in the class would be expected to read a portion of the article entitled Two Rivers. This article is taken from the Association of American Geographers high school project and is suitable for the study of land-use patterns at the high school level. The students would read pages 13-17 and be expected to answer questions orally about the article (which has been reproduced and included in the following pages).

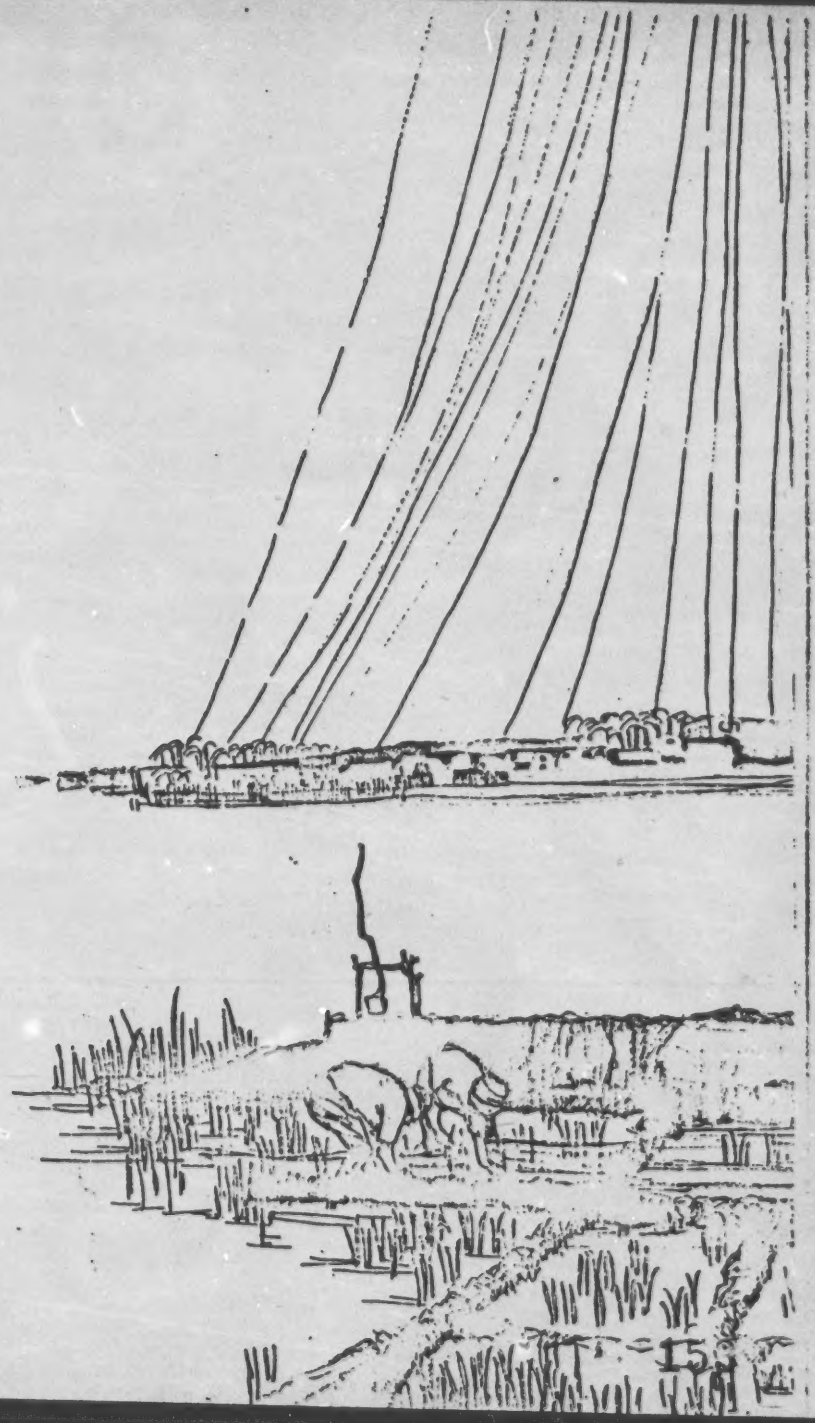
Two Rivers

In this activity you will study two very similar habitats—the lower Nile River and Delta area in Egypt (United Arab Republic) and the Salton Sea area in southeastern California. Both are dry regions that would be deserts if a river did not provide water to make them places where man could live.

Yet these two areas are used differently by man. Why?

Some of the answers to this perplexing question are given in the two readings that follow. And you have learned some of the reasons in the other units of *Geography in an Urban Age*.

As you read, keep in mind the possible answers to the question, for you will be asked to discuss them later.



THE NILE HABITAT

The Nile, with a length of 4,100 miles, is the longest river on earth and the only major river that flows from south to north. Imaginative people have compared it to a flower. The river is the long slender stem and the delta is the large blossom. There is even a bud. It is an area which lies well below sea level west of the river not far from the delta and is called Al Fayyum.

The Nile's principal sources, near the equator, get a peak of heavy tropical rains from March to September. By July this peak of water flowing north has converged on the main channels of the river as they cross Sudan and the United Arab Republic.

Because the volume of water was much greater at this time of year than the channels could hold, the river always used to overflow its banks. The flood stage would last until October. Until man began to remodel the landscape, the Nile Valley was under a sheet of water with only ridges of higher ground rising above the flood. Since Egypt receives almost no rainfall, the valley of the lower Nile gets almost all of its water for the entire year from the Nile during the few months of its high water flow.

Rather than being a natural disaster, the annual flood permitted the rise of one of the richest, most advanced of ancient civilizations by 3000 B.C. The yearly flood helped the people to grow food to support a large population and to free men for building, learning, and art. Herodotus, a Greek geographer-historian of the fifth century B.C., wrote that Egypt was the "gift of the Nile."

The flood waters of the Nile carried soil particles from upstream and deposited them over the flood plain. The flood plain of a river is all the land its flood waters cover at their highest stage. If the river runs through a narrow valley with steep walls on both sides, it will have very little flood plain. But if it flows through a somewhat broader valley—as does the lower Nile—its flood plain may be several miles wide.

For thousands of years the silt deposited each year by the flood partly renewed the fertility of the Egyptian fields along the banks of the Nile. Man had to do little except plant after the water receded.

Deltas, like flood plains, are formed by soil deposits. As the Nile reached sea level it flowed too slowly to keep the particles in the water moving. So, as the river emptied into the Mediterranean Sea, the soil particles dropped out of the water and eventually built up into land. The Nile Delta happens to have the triangular shape of the Greek letter delta, which is written △. At the point the Nile River reaches the delta it breaks up into a number of smaller channels that cut through the flat soil deposits.

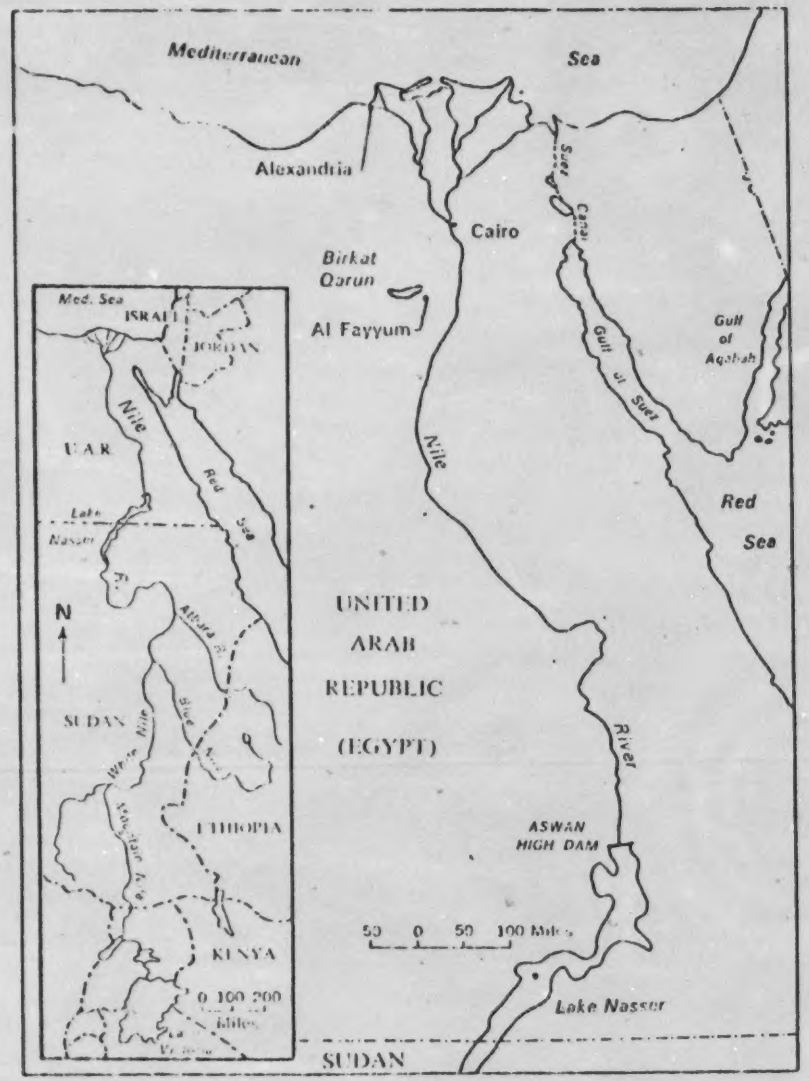
Man Begins to Remodel the Landscape

Fields and the villages built on stretches of high ground that seldom were flooded or on the desert margin of the flood plain were the major changes ancient man made in the landscape of the valley and the delta. After the water receded in the fall, fields were planted. Crops grew during the warm dry winter and were havested in the spring.

On either side of the fertile flood plain and delta was, and still is, the desert. As of today, nineteen of every twenty Egyptians live either on the flood plain or on the river's delta, which together are only 3½ per cent of the country's area.

No other major modifications were made in the Nile habitat until about 3400 B.C. when a great technological revolution began. Egyptian farmers learned to use plows instead of planting seed in the natural furrows left by departing flood water. Also, man began to devise ways to manage the flow of the water. Earth embankments were

THE NILE VALLEY AND DELTA



built to control the movement of flood waters so that water could be led to more of the shallow natural basins within the flood plain, and therefore cover more land. Basin irrigation thus gradually evolved. Lake Moeris (present-day Birkat Qarun) in Al Fayyum was another early water-control device. Excessive floods could be diverted there and in years of deficient flood, water could be let back into the valley.

Winter crops were grown: wheat and barley, also vegetables and flax. At the time of Nero, about 60 A.D., Egypt provided Rome with wheat for four months of the year.

In a few places where water could be secured all year round, more and varied crops could be grown. Thus, a little year-round irrigation began. Perhaps the idea came from the times when ponds of water were left behind in low areas after the flood receded. Water then could be carried in buckets to other fields. Lifting machines, first the pole and bucket type, later the water wheel, were brought into use. In some places, water from underground wells could supplement the flood supply and also help to make year-long cultivation of the land possible.

On lands which had year-round irrigation, more than one crop could be grown each year, and the food supply increased. By the time these changes had taken place, ancient Egypt had 6 million acres under cultivation and supported a population that may have been more than 7 million. Grain was Egypt's chief export.

Decline of Egyptian Agriculture

But Egyptian agriculture began to decline. The reasons for the decline were many. The country's farms lost much of their power to produce. When land is irrigated year after year but not drained, the water evaporates, leaving behind salts that destroy soil fertility and the salts eventually ruin the soil for farming.

This happened to many Egyptian farms in the delta and flood plain. Besides, in one great disaster a million and one-half acres in the delta were ruined by sea water sometime in the late Roman or early Arab periods.

As farms failed, embankments and irrigation works fell into disrepair. Plagues and epidemics followed. By the time of the Arab conquest in the 600's, the population had dwindled considerably. In the Middle Ages the productivity of the land continued to drop.

But beginning about 1820, changes which greatly lengthened the growing season were made. First, irrigation canals were dug deeper so that even low water in summer before the floods came could be diverted into many fields. But the canals had to be dug out every year after the receding floods silted them, work requiring hundreds of thousands of men. So instead of deepening canals, Egyptians built earth barriers or small dams to raise the summer water level at intervals all along the river, forcing the water to spill over into shallow canals. By 1890 this system had lifted the general summer level of water more than twelve feet. In the delta of the Nile it became possible to grow crops throughout the year. More summer crops could be grown; they commanded a better world market. Other crops could then be planted after the floods.

Egypt turned to growing cotton in a big way. Until summer irrigation became possible on a large scale, cotton had been a minor crop because flax fared better as a winter crop. So much land was used for cotton that Egypt had difficulty in growing enough food for its people. Indian corn, or maize, which is a summer crop, also began to replace wheat as the staple food of Egyptian peasants.

Early in the twentieth century, more ambitious water control started with the building of the first Aswan Dam in 1902. The system of small barriers in the Nile used the water inefficiently. The dam was designed in part to

store some of the Nile's flood waters. The previous barriers constructed along the river had not stored any flood water for later use, but only raised the level of river water so that water would flow into intake canals. The Aswan Dam was heightened in 1912 and again in 1933. Now a new dam, the Aswan High Dam, has been constructed big enough to hold back an entire annual flow of the Nile. It will also provide power to make cheap fertilizers, badly needed by the intensively cultivated farms that are no longer covered by silty Nile water which previously had renewed soil fertility.

Good and Bad Effects

At present four fifths of Egypt's farms are irrigated for summer crops and the appearance of the flood plain has been greatly altered. Never does a sheet of water cover it. That once life-giving aspect of the Nile would be a major disaster, destroying the summer crops which are the most valuable of all. The flood's mud and silt, once believed to be a necessity for recharging the fertility of the land, are now considered a nuisance by many because they fill up the canals.

The river itself is kept in its channel by artificial high banks pierced by hundreds of canals which take the water to the fields. Gradually the amount of land farmed increased, until today it is back to the 6 million acres of ancient times. Furthermore, because so much land is cropped twice and even three times a year, the effect is as if Egypt had more than 10 million single-crop acres under cultivation.

Cotton is still the biggest cash crop. It is suited to larger fields so it is popular with larger landowners. Recently, as the cities grew larger, wheat acreage has increased again because urban people prefer wheat to corn.

Irrigation and multiple cropping have brought their own problems. When year-round irrigation is practiced, the soil becomes waterlogged. Without proper drainage, so much water remains near the surface that it can keep the roots of plants from "breathing." The salt content also has increased since salts can be removed only by flushing water through the soil and then draining off the water. Because of these conditions, some authorities believe that good drainage for delta farms is as important to the future of Egypt as is the Aswan High Dam.

Insects, almost unknown in the dry Egyptian climate a century or so ago, now seriously damage some crops. The increased moisture in the soil and air has created a favorable habitat for such pests as the boll weevil.

Recent Changes

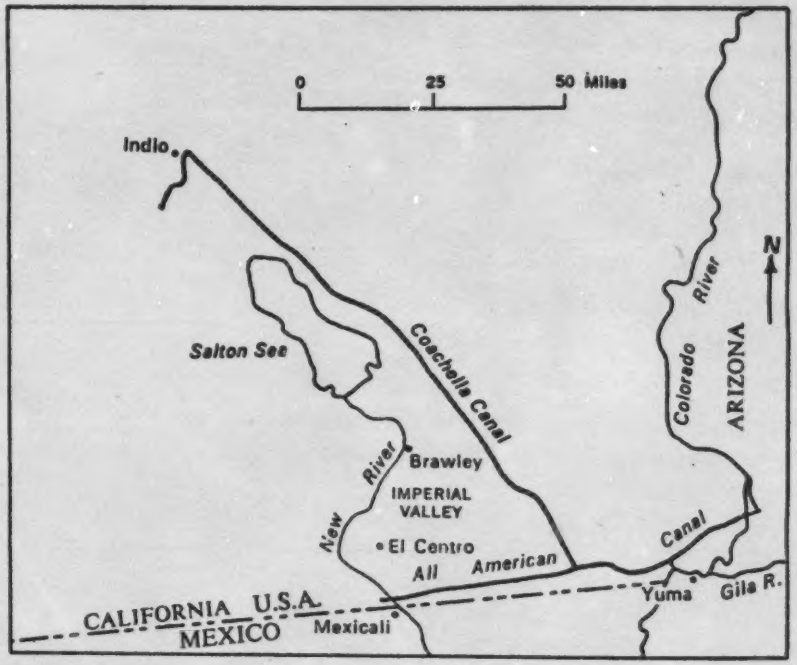
The most recent changes in land and water use in the Nile Valley are related to changes in Egypt's political organization. In 1952 a socialist form of government replaced the old monarchy. Land reform laws limited the amount any man could own and large land holdings were broken up and sold to peasants. By American standards, most of the farms are extremely small, and most of the farmers come to the fields from nearby villages just as they have for centuries. The government undertook the new Aswan project, a dam large enough to store more than 100 million acre-feet of water, three times the capacity of Lake Mead behind Hoover Dam on the Colorado River. The aim is to make possible at reasonable cost the year-round irrigation of many areas that still lack it, and bring 1 to 2 million new acres under cultivation.

SALTON SEA AREA

The Colorado River flows 1,400 miles southwestward through mountains and desert from its source in the Colorado Rockies before it empties into the Gulf of California. It is the largest river in the American Southwest.

THE COLORADO RIVER AND SALTON SEA

Area covered on map at right



Irrigated areas

People living in seven states and in Mexico use its water. Like the Nile, it is an international river.

Most of the upper and middle portions of the river's basin is rough mountainous country into which the river has cut an immense gorge. The most spectacular portion of the gorge is the Grand Canyon. South of Hoover Dam the landscape becomes more subdued, and the Colorado has built a flood plain and a large delta upon which agriculture was developed. Today, the California-Mexico border passes through the delta.

Indians living along the lower Colorado developed a form of agriculture similar to that of the early Egyptians long before white men ever saw the area. But because the Colorado flooded in late spring, the crops were planted and grown in the hot summer months. Corn, beans, and squash were staple items.

A part of the Colorado River water is used in a hot, dry depression, or basin, toward the center of which is the Salton Sea. Although the area appears to be similar to the Nile Valley, the development here has been very unlike that of Egypt. The Americans began to modify the habitat in a region of sparse population thousands of years later than did the Egyptians. In addition, the Americans have larger capital resources than the Egyptians, use

many more machines, farm larger fields, and employ laborers who work in the fields by day and go home to nearby towns at night. There are no large cities. Yet, like Egypt, the economy of the whole area is dependent on the flow of one river—the Colorado.

Long before Americans settled in this region, the river emptied its water from time to time into a depression about eighty miles west of its channel. A body of water, Lake Cahuilla, existed there until several hundred years ago.

The Salton Sea basin is an elongated valley, an extension of the trough that forms the Gulf of California. The part of the basin that is north of the Salton Sea is called the Coachella Valley, while that part south of the Salton Sea is called the Imperial Valley. Much of the basin lies below sea level, the lowest point 277 feet below the surface of the Gulf of California. A low ridge, a portion of the delta fan of the Colorado, separates the basin from the gulf. Mountains rise abruptly above the sides of the basin in all other directions.

Early Spanish settlers of the 1700's avoided this desert as no sea or lake existed there. Only a few explorers crossed it. Americans seeking gold tried this route into California, but many lives were lost in the blazing desert. Only after railroads were built in the 1870–1880's through the region did men begin to think of turning the desert into farms.

The bottom of the basin lay below sea level, but only a few miles to the southeast the Colorado River flowed across its delta more than fifty feet above sea level. It seemed to be a simple matter to construct canals to bring Colorado River water into the basin and, hopefully, to turn the dry desert into green farm land.

The first canal was cut through the river bank near the Mexican border in 1901. The valley was renamed the Imperial Valley to change its image to attract farmers and settlers.

The new canal was not trouble-free, for the tremendous amount of silt carried by the Colorado began to fill up the canal intake. New openings were made. But nature had another card to play. Although most people did not realize it, the entire Colorado River basin had been in a period of drought since the 1890's. In 1905 an exceptionally high Colorado flood poured into the valley along this canal and created the Salton Sea.

After many attempts over a period of years, the break in the river bank was closed and irrigation of the Imperial Valley resumed. Still, there existed many problems with the landowners, water companies, railroad, and Mexican government. Besides, the river was still not fully regulated and in periods of low water, fields were dry. The threat of another flood remained, too.

The building of Hoover Dam and other large dams along the Colorado ended both these dangers. A system of canals has been constructed to carry water to the fields. Underground drains have been installed to carry away excess water. This means that much of the area can be farmed without the danger of waterlogging or salting that the Nile Valley has suffered. The main intake canal has a series of settling basins in which the river silt is taken out before it gets to the fields.

Farming as Big Business

The typical Imperial Valley ranch is an industrial farm of several hundred acres which a farmer may lease from someone else. Many belong to corporations, so a farm may be run by the owner or may belong to absentee stockholders. Few people live on the farms. Owners and workers live in small towns and cities of the valley. Most settlements are shipping points and market centers located on rail lines connecting them to eastern markets.

The Imperial Valley farms are highly mechanized. Many operations are carried out by huge custom outfits

moving from farm to farm. These farms no longer employ hand labor, needing only the men who run the machines.

Production per acre is high. On some land two or three crops per year are grown, such as cotton, lettuce, sugar beets, tomatoes, cantaloupes, watermelons, and carrots. A rather important livestock feeding industry is also located in the valley. Beef cattle and lambs are fattened on alfalfa, sugar beet pulp, cotton seed meal, and molasses.

The Coachella Valley to the northwest of the Salton Sea has a different type of soil. Fruit is grown here. Ninety per cent of United States dates are grown there, as well as seedless grapes and citrus fruits. The Coachella Valley was originally irrigated from artesian wells. Later a branch of the canal from the Colorado was built around the Salton Sea to bring additional water to this valley's farms.

A rather important recreational industry has grown up around the Salton Sea since it was created. Many beach cottages and homes have been built along its shores. When the Imperial Valley farmers irrigate their crops, surplus water eventually flows into the Salton Sea.

The farm drainage system also carries salts flushed from the soil to help preserve the fertility of the land. Some sewage from the towns and cities also empties into the man-made sea.

The farmers of the valley still have problems, like the boll weevil which often damages the cotton crop. But the change the Americans have made in the area's landscape is even greater and took place in a far shorter time than that the Egyptians have made in the Nile Valley. The change was from an almost uninhabited desert to a highly productive farming region. While far from being as densely populated as the Nile flood plain, its 500,000 acres support thousands of people prosperously.

Objective 2: Determining Ekistic Elements

According to the science of ekistics, the study of human settlements must be broken down into five major elements to help the teacher and students organize their perceptions and understanding of the relevant phenomena. The students would have had a prior introduction to the study of human settlements and they should be able to recognize the ekistic elements particularly relevant to the case-study. We are looking at land-use patterns, hence the ekistic element under study would be Nature. However, the students must be reminded that the other four elements making up the study of human settlements are also interacting with Nature.

Objective 3: Identification of Community Scale

The third objective would follow very closely with our second in that the students, through the use of the modified ekistic grid (see Figure II-4), are to determine what community scale they are investigating. After reviewing the modified ekistic grid, and following a class discussion about the relevant social, political, and economic factors of the Egyptian delta region, the students would be asked to select what appropriate community scale is being investigated. In this instance, it appears that the class should identify the appropriate community scale as being a conurbation.

The outcome from the implementation of the first three objectives of the recommended lesson plan is to have students:

- become familiar with the content material of the case study;
- select the relevant human settlement elements; and
- determine the appropriate community scale according to the taxonomy of the modified ekistic grid.

The intent of the remaining objectives of Table IV-1 is to focus the students' attention on the "Decline of Egyptian Agriculture", using the policy sciences perspective. We believe this approach is important because it allows students and teachers to share their perceptions about a complex problem and to discuss alternative courses of actions that could contribute to the achievement of the most desirable outcome. As the students become familiar with the policy perspective, they can gradually be exposed to more complex problems. Since this case represents a first attempt to perform a policy analysis on a human settlement entity, it might be preferable to have the students work out their perceptions in groups of 3-5, depending on the size of the class. As the students become more adept with the policy perspective approach, they could be allowed to work individually.

Objective 4: List of Problem Elements

During the element identification phase of our lesson, each group in the class will develop a list of elements which they perceive as interacting with one another and contributing to the overall problem situation, i.e., to a decline in agricultural production within Egypt. Each class group, through discussion and consensus, might produce a problem element list that looks like the one shown in Table IV-2.

TABLE IV-2: IDENTIFICATION OF PROBLEM ELEMENTS

P_1. Irrigation canals are dug deeper to catch more water.
P_2. Construction of earth barriers.
P_3. More summer crops are grown.
P_4. Increase in cotton production as a cash crop.
P_5. Fewer acres of staple crops are planted.
P_6. Construction of Aswan Dam Project.
P_7. Entire flow of Nile River under control of dam system.
P_8. Increased use of fertilizers.
P_9. Less natural silt deposit on land.
P_{10}. Flooding of silt delta lands from the Nile has ceased.
P_{11}. Year-round irrigation practiced.
P_{12}. Soil becomes "waterlogged."
P_{13}. Poor drainage of irrigated land in delta region.
P_{14}. Salt content of soil increases.
P_{15}. Increase of pests and boll weevils.
P_{16}. Lack of "breathing" for roots of crops planted.
P_{17}. Weather and climate conditions require extensive irrigation for farming.
P_{18}. Drop in crop production per acre.

When the groups develop their different element lists, they will reflect on many of the various elements which can contribute to the loss of agricultural production.

Since this is the students' first attempt at this activity, the teacher would have each group present their findings so far. This would allow for an open discussion and provide a useful mechanism for checking each group's individual progress. Further, as we have noted in our lesson plan, the teacher could give other reading material similar to the Two Rivers article to determine if the students are able to develop a list of problem elements. After the completion of the different lesson objectives, it is important that the teacher monitors each group's progress to be sure that they have successfully completed the original objective. As the students gain additional experience utilizing the policy perspective approach, such close monitoring may not be necessary.

Objective 5a: Understanding Goals of Policy Science

With the completion of each group's set of elements the different groups would begin the heart of the policy process. The intent of Objective 5a is for the teacher to review with the groups the dimensions of policy sciences before they apply the five step problem-orientation sequence. The various groups would be reminded that policy science is represented by some form of human intervention in the operation of a system in order to achieve the desired goals of that system. In this instance, the students would realize that they are going to recommend certain policy initiatives which will help to stop the continued decline in agricultural production in the Egyptian delta region.

During the five step problem-orientation analysis, the students would also be using the "framework for the Conceptualization of Settlement Futures and the Selection of A Desirable Future" (see Figure II-5).

Objective 5b: Goals Clarification

By means of Objective 4 each group has identified a number of problem elements (see Table IV-2), and they essentially have gained a greater appreciation of the complexity of the problem situation they are studying. Based on their perception of the problem each group can list some desirable futures concerning land-use patterns in the delta region of Egypt. By examining their particular problem list each group could devise the following exemplary list of goals for this region:

G_1. Better soil drainage for the delta area.
G_2. Increased crop production.
G_3. Planting of more acres of staple crops

G_4. Reduction in the failure of small family farms.
G_5. Others.

Objective 5c: Trend Extrapolation

This step of the process allows the different groups to project the probable futures of agricultural production, if current land-use patterns are allowed to continue as they have in the past. During this step students could ask questions like: "What will the social, political, and economic consequences be in 10 to 20 years if certain policy initiatives are not implemented?"

Once the groups have generated answers to some of their questions, they could list likely events which might occur if local officials fail to attempt to alter present land-use trends, as shown in Table IV-3.

TABLE IV-3: TRENDS WITHOUT ANY POLICY INTERVENTION

T_1. Soil will become completely "waterlogged."
T_2. Salt concentrations and the number of insects rise to a level which all but prohibits farming.
T_3. After continued use of fertilizer, crop yields begin to decline.
T_4. Unemployment begins to rise as farmers are forced to stop farming.
T_5. Already overcrowded cities must absorb those farmers who leave their lands.

With the utilization of this particular exercise, students have now become increasingly sensitized to the need of some form of policy intervention to prevent these probable trends from occurring.

Objective 5d: Problem Identification

At this point each group can now focus on the primary elements which are contributing to land-use problems in the Egyptian delta region. By referring to their original list of problem elements (see Table IV-2), each group can now refine their list to focus on the problem elements which are interfering with the achievement of regional goals described in Objective 5b. The groups would be reminded that as they develop the problem lists, they have an opportunity to focus on the difference between their desirable futures as described in Objective 5b and the probable futures as developed in Objective 5c. The discrepancies between the desirable and probable futures represent the real problems that regional policy initiatives must attempt to resolve.

Table IV-4 represents the major problem elements interfering with the attainment of regional goals as listed under Objective 5b.

TABLE IV-4: PROBLEM ELEMENTS INTERFERING WITH ACHIEVEMENT OF GOALS

P_1. Increase of cotton production as a cash crop.
P_2. Fewer acres of staple crops planted.
P_3. Construction of Aswan Dam.
P_4. Increased use of fertilizer.
P_5. Flooding of farm land has ceased.
P_6. Year-round irrigation practiced.

P_7. Soil is becoming increasingly "waterlogged."
P_8. Poor drainage or irrigation land in delta region.
P_9. Continued build-up in salt content of the soil.
P_{10}. Increased problem of insects.
P_{11}. Lack of "breathing" capabilities for roots of crops planted.
P_{12}. Reduction in crop production.

Objective 5e: Analysis of Conditions

At this point in the process each group could review the work they have completed so far. The intent would be for the different groups to analyze the list of problem elements developed in Objective 5d. The students would try to determine how these elements interact with one another. One way the different groups could explore the relationship among the elements is by applying the Interpretive Structural Modeling technique. Each group, with help of the teacher serving as a facilitator, could engage in an ISM exercise, as described in Chapter III. By utilizing ISM each group might produce a structure similar to the one shown in Figure IV-1. This structure demonstrates the linkages between problems through a "cause or affects" relationship.

By carefully analyzing the structural model shown in Figure IV-1 the students can appreciate the causal linkages that exist among the problem elements and how each problem contributes to the fundamental problem appearing at the top of the hierarchical structure, namely "Reduction in Crop Production" in the Egyptian delta region.

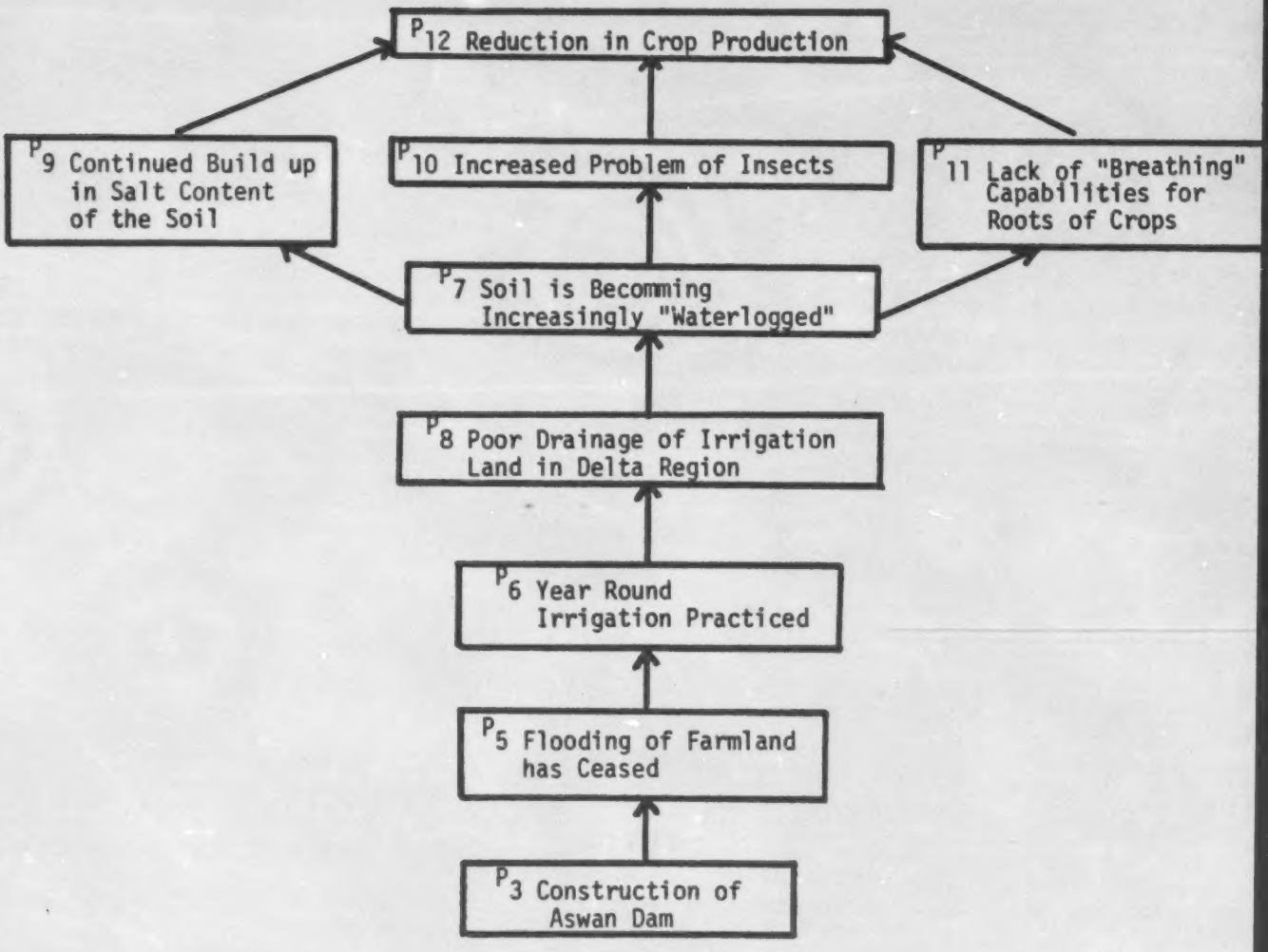

P12 Reduction in Crop Production
P9 Continued Build up in Salt Content of the Soil
P10 Increased Problem of Insects
P11 Lack of "Breathing" Capabilities for Roots of Crops
P7 Soil is Becomming Increasingly "Waterlogged"
P8 Poor Drainage of Irrigation Land in Delta Region
P6 Year Round Irrigation Practiced
P5 Flooding of Farmland has Ceased
P3 Construction of Aswan Dam

FIGURE IV-1: A PERCEPTION OF LINKAGES AMONG PROBLEMS THROUGH A "CAUSES OR AFFECTS" RELATIONSHIP.

The question that the group must address now is what kind of intervention might ameliorate the problem situation depicted by the ISM model. One of the major regional goals identified earlier by the group of students was "Increased Crop Production". They are now ready to explore what alternative actions could be adopted by regional policy-makers to achieve the desired regional goal.

Objective 5f: Invention, Evaluation, and Selection of Alternatives

In this final step each group would explore alternative policy actions to achieve their desired regional goals.

During the process each group of students could utilize the ISM model they developed during Objective 5e. In this case the group of students that developed the ISM model shown in Figure IV-1 would examine the ISM model to determine what policy options might exist pertaining to each particular problem element.

For example, the group would determine that P_3, "Construction of Aswan Dam", represents a problem element for which no policy option exists because nothing can be done to alter the fact that the dam exist. Further, since the dam will continue to prevent flooding to the delta farmlands, year-round irrigation would still have to be practiced. Thus, after examining P_3, P_5, and P_6 the group would move to problem element P_8, "Poor Drainage of Irrigation Land in the Delta Region". It is at this level that the group of students would conclude that the essential policy recommendation is the improvement of drainage for the irrigated lands in the Egyptian delta region. The initiation of this policy option would have a positive affect on all the other problem elements contained within the problem situation they have been studying. Figure IV-2 represents how the group of students can reconstruct the linkages among the elements of Figure IV-1 by introducing a policy intervention that will contribute to the attainment of the regional goal, "Increased Crop Production".

Essentially with the completion of this final lesson objective the students have concluded the policy analysis process. During these various steps the student groups have examined a complex problem, broken it down into its "problem elements", and developed an ISM model to help analyze linkages among the various "problem elements". With the utilization of the policy process students will be able to invent and recommend policy initiatives to help achieve regional goals.

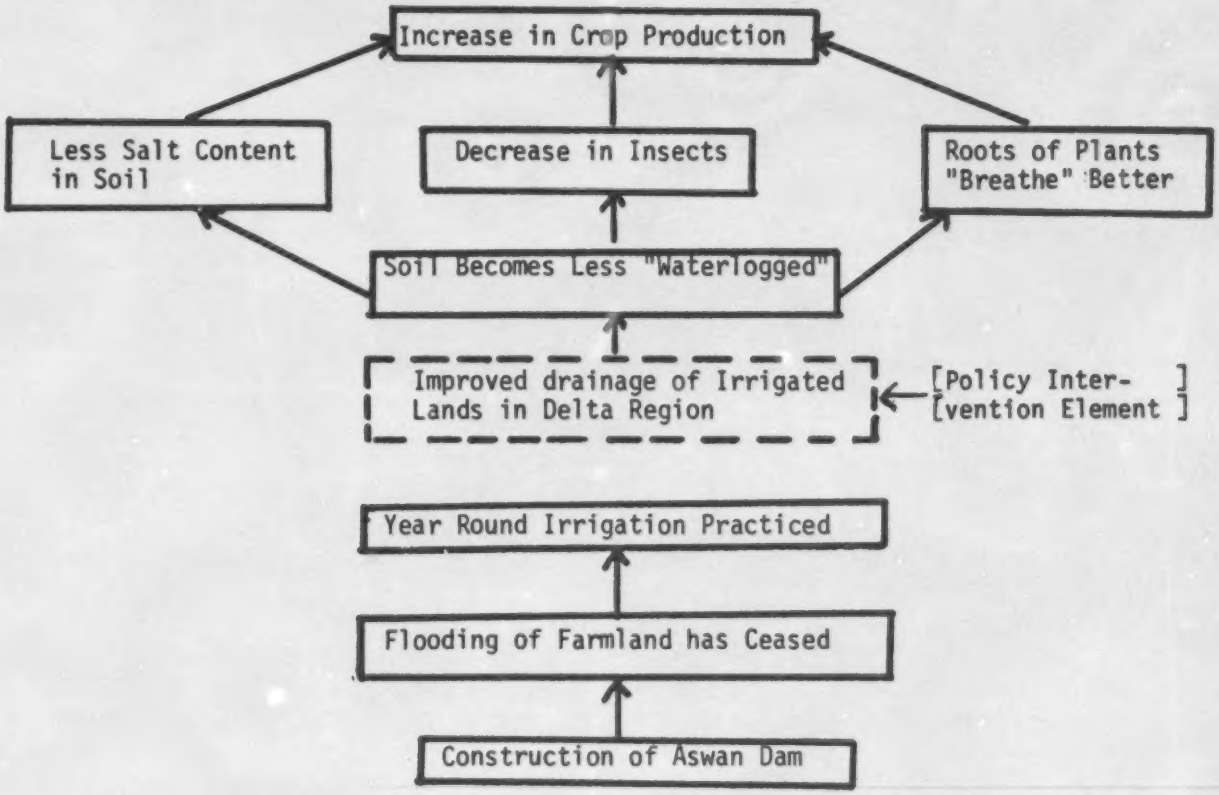

Increase in Crop Production
Less Salt Content in Soil
Decrease in Insects
Roots of Plants "Breathe" Better
Soil Becomes Less "Waterlogged"
Improved drainage of Irrigated Lands in Delta Region
[Policy Inter-]
[vention Element]
Year Round Irrigation Practiced
Flooding of Farmland has Ceased
Construction of Aswan Dam

FIGURE IV-2: A PERCEPTION OF LINKAGE AMONG ELEMENTS FOR THE ATTAINMENT OF THE REGIONAL GOAL. THE RELATIONSHIP IS "CAUSES OR AFFECTS".

CASE TWO: A METROPOLITAN REGION

The second application example focuses on a metropolitan area corresponding to community scale No. 7 on the ekistic grid, i.e., an approximate population of two million people.

In this application the class will utilize the two techniques presented in Chapter II in order to generate and structure ideas relating to the particular metropolitan area in which their high school is located. The role of the teacher is that of a discussion leader. The role of the students is primarily to engage in a dialogue and to generate ideas relevant to the goals and problems of their metropolitan region.

In this case, the ekistic entity for study has been defined by the group from the outset. Hence, they can immediately proceed to the application of the policy perspective in the framework of the system for inquiry approach.

Step 1: Goal Clarification

With the teacher acting as a discussion leader the class will conduct a Nominal Group Technique to generate a set of metropolitan goals. The application of NGT will most likely take from two to three hours and might lead to a set of goals similar to the one shown in Table IV-5.

TABLE IV-5: A SET OF METROPOLITAN SETTLEMENT GOALS

G_1. To enhance the quality of human life in all its dimensions.

G_2. To preserve the quality of the natural environment.

G_3. To maximize recycling of depletable resources.

G_4. To enhance the quality of renewable resources.

G_5. To achieve a balance between population and resource utilization.

G_6. To provide recreational activities and open spaces.

G_7. To satisfy Man's physiological needs.

G_8. To provide for the safety and security of all citizens.

G_9. To provide cultural and aesthetic opportunities for human development and self actualization.

G_{10}. To provide an environment supporting diversity and variety of individual choices.

G_{11}. To provide a system of law and justice for all citizens.

G_{12}. To provide all the social and educational needs of the population.

G_{13}. To supply adequate employment and economic opportunities.

G_{14}. To provide adequate and diversified housing.

G_{15}. To provide hospital and emergency services.

G_{16}. To provide shopping and manufacturing opportunities.

G_{17}. To provide educational and cultural centers (opera, stadium, zoo, etc.)

G_{18}. To provide water, energy, and waste-disposal networks.

G_{19}. To provide private and public transit networks.

G_{20}. To provide communication networks.

G_{21}. To provide computer and information service networks.

After discussing and clarifying the meaning of each one of the goals displayed in Table IV-5, the teacher will engage the class in an ISM process as described in Chapter III.

Given the number of goals displayed in Table IV-5, it will take approximately three hours of classroom time to generate a metropolitan goals structure similar to the one shown in Figure IV-3.

After the structure has been generated by the use of the ISM process, the class should engage in a discussion in order to comprehend how the lower-level goals are instrumental to the achievement of the higher-level goals. Also it will be useful for the remaining steps of the policy science process to attempt to cluster the goals into main sectors for analysis. For example in the case of Figure IV-3, it is interesting to notice that the goals structure can be subdivided into three separate and interrelated sectors, namely: (a) the ecological sector which is relevant primarily to the ekistic element corresponding to Nature, (b) the land-use/transportation sector which is linked to the ekistic elements of Nature and Networks, and (c) the socio-economic sector corresponding to Society. The class might choose to look at each one of those elements of Ekistics more carefully during their study of the metropolitan region. Or they might choose to divide into three groups, each one concentrating and analyzing one of the three sectors identified in Figure IV-3.

Step 2: Trend Extrapolation

During this step of the policy process the teacher might engage the students in identifying present trends within the metropolitan area and trying to extrapolate them into the future in order to derive probable future states of the metropolis. Examples of such trends might be:

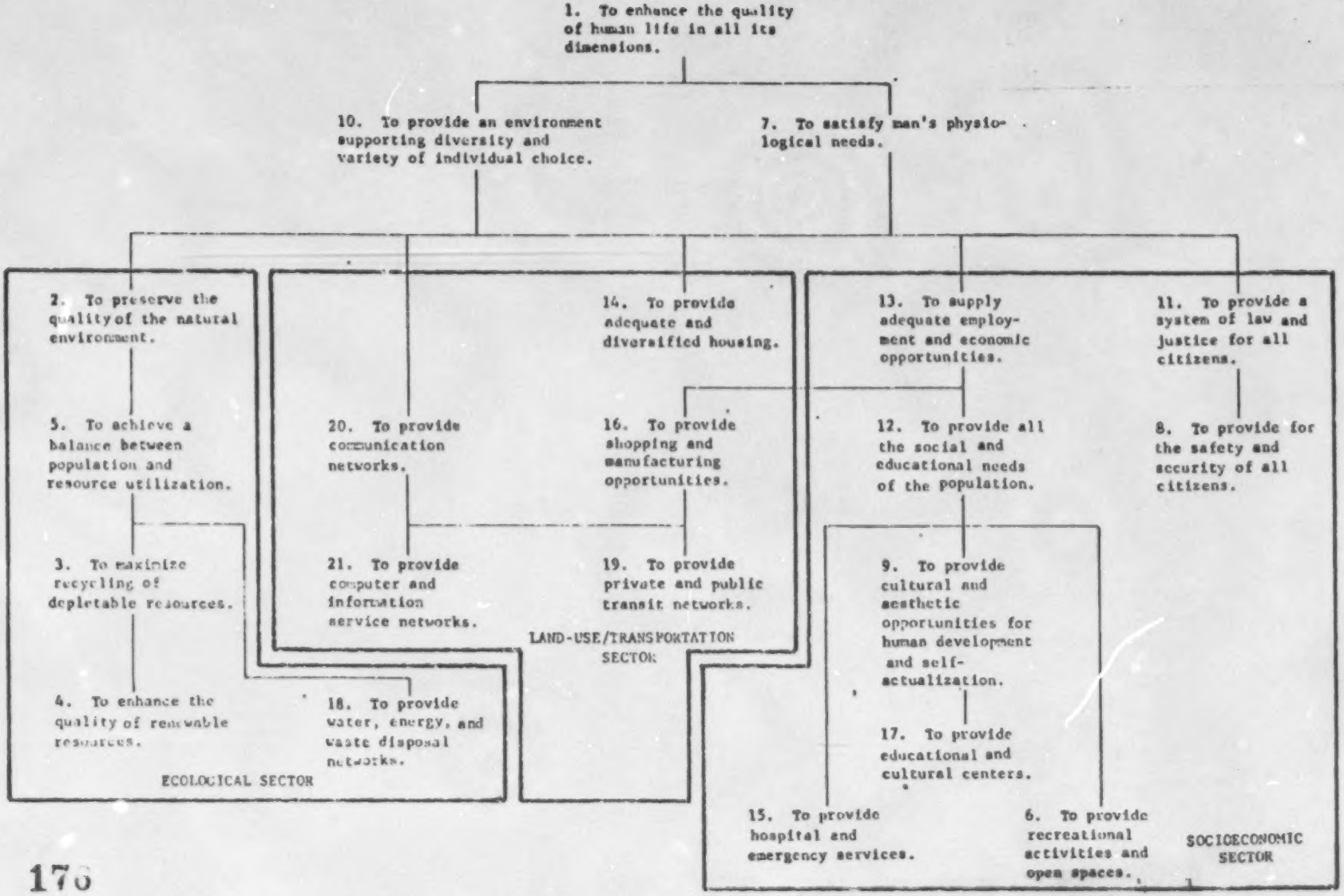

1. To enhance the quality of human life in all its dimensions.
10. To provide an environment supporting diversity and variety of individual choice.
7. To satisfy man's physiological needs.
2. To preserve the quality of the natural environment.
5. To achieve a balance between population and resource utilization.
3. To maximize recycling of depletable resources.
4. To enhance the quality of renewable resources.
18. To provide water, energy, and waste disposal networks.
ECOLOGICAL SECTOR
14. To provide adequate and diversified housing.
20. To provide communication networks.
16. To provide shopping and manufacturing opportunities.
21. To provide computer and information service networks.
19. To provide private and public transit networks.
LAND-USE/TRANSPORTATION SECTOR
13. To supply adequate employment and economic opportunities.
11. To provide a system of law and justice for all citizens.
12. To provide all the social and educational needs of the population.
8. To provide for the safety and security of all citizens.
9. To provide cultural and aesthetic opportunities for human development and self-actualization.
17. To provide educational and cultural centers.
15. To provide hospital and emergency services.
6. To provide recreational activities and open spaces.
SOCIOECONOMIC SECTOR

Figure IV-3: A METROPOLITAN GOALS STRUCTURE (LOWER LEVEL GOALS . . ARE CONSIDERED TO BE INSTRUMENTAL TO ACHIEVEMENT OF HIGHER LEVEL GOALS).

T_1. Unemployment in the central city to increase to approximately 12% by 1980;

T_2. An increasing need for an improved public transportation system;

T_3. Increased air pollution in the central city;

T_4. Increased density in downtown area due to high rise construction;

etc.

The class should engage in a discussion of these foreseeable trends and determine the extent to which they are compatible with the metropolitan goals identified in Step 1 of the process.

Step 3: Problem Identification

The focus of this step is to develop a deeper understanding of the meaning of a specified set of problem statements and to establish a pattern for their interaction.

The teacher should use the NGT technique to generate a list or problems in the light of Steps 1 and 2 of the policy process discussed previously. An exemplary set of problems is shown in Table IV-6.

TABLE IV-6: STEP 3: PROBLEM IDENTIFICATION, A METROPOLITAN PROBLEM SET

P_1. Misuse of agricultural and urban land.
P_2. Urban sprawl.
P_3. Destruction of natural and recreational land.
P_4. Lack of adequate open spaces and parks.
P_5. Air pollution.
P_6. Water pollution.
P_7. Inadequate water supply facilities.
P_8. Low income housing shortage.
P_9. Racial and economic segregation.
P_{10}. Inadequate community facilities.
P_{11}. Slums.
P_{12}. Ugliness of visual and noisiness of auditory environment.
P_{13}. Discrimination, unequal opportunities.
P_{14}. Inadequate schools and education.
P_{15}. Civil order breakdown.
P_{16}. Lack of concern for human lives in the city.
P_{17}. Policy-action impotence caused by diffusion of political power.
P_{18}. Lack of effective control of resources for protection of public interest.
P_{19}. Flight to suburbs of middle class.
P_{20}. Urban renewal/relocation problems.
P_{21}. Unemployment and poverty: underprivileged, unskilled, uneducated, racial discrimination.
P_{22}. Bankruptcy of cities.
P_{23}. Property tax revenue base of local government.
P_{24}. Economic dependence of communities on industries.
P_{25}. Inadequate solid waste disposal.
P_{26}. Lack of adequate intra-city transportation modes.
P_{27}. Traffic noise and fumes.
P_{28}. Neighborhood destruction by freeways.
P_{29}. Alienation, disorientation.
P_{30}. Difficulty of coping with constant change.

Given the problem set of Table IV-6, the teacher should lead an ISM exercise to construct a structure similar to the one shown in Figure IV-4. A useful relation for generating a problem structure is the relation "aggravates." This structure essentially portrays graphically how a problem aggravates other problems of the metropolitan set. It primarily helps in identifying those problems that are more critical in the sense that they represent a source of aggravation. It also portrays by means of "cycles" the subset of problems that are clustered together in a strongly interconnected system of problems. In this particular example, there appears to be a cycle containing the twenty-one problem statements shown in Table IV-7. This table collects those problem statements which were perceived in this case as being involved in a complex substructure involving feedback loops in such a manner that each component problem was seen as aggravating every other problem in the subset. The problem statement P_9, Racial and Economic Segregation, is identified as the "principal generating element" because it was selected as the problem statement upon which to base the pair-wise comparison of elements as required by the ISM technique.

TABLE IV-7: A PERCEPTION OF URBAN PROBLEM LINKAGES USING THE RELATION "AGGRAVATES": CYCLIC COMPONENTS

Principal Generating Element:

P_9. Racial and economic segregation.

Remaining elements:

P_1. Misuse of agricultural and urban land.
P_2. Urban sprawl.

TABLE IV-7 (continued)

P_4. Lack of adequate open spaces and parks.

P_8. Low income housing shortage.

P_{10}. Inadequate community facilities.

P_{11}. Slums.

P_{12}. Ugliness of visual and noisiness of auditory environment.

P_{13}. Discrimination, unequal opportunities.

P_{14}. Inadequate schools and education.

P_{15}. Civil order breakdown.

P_{16}. Lack of concern for human lives in the city.

P_{18}. Lack of effective control of resources for protection of the public interest

P_{19}. Flight to suburbs of middle class.

P_{20}. Urban renewal/relocation problems.

P_{21}. Unemployment and poverty: underprivileged, unskilled, uneducated, racial discrimination.

P_{22}. Bankruptcy of cities.

P_{23}. Property tax revenue base of local government.

P_{26}. Lack of adequate intra-city transportation modes.

P_{29}. Alienation, disorientation.

P_{30}. Difficulty of coping with constant change.

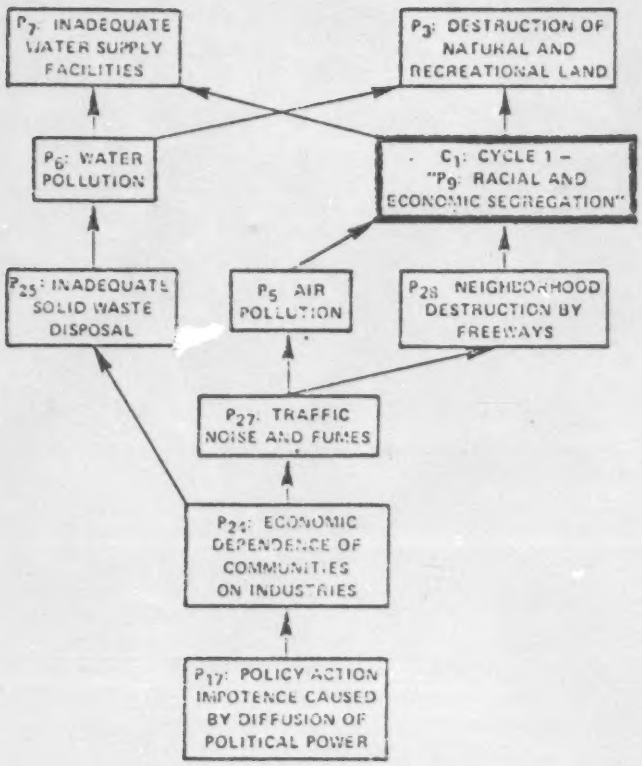

P7: INADEQUATE WATER SUPPLY FACILITIES
P3: DESTRUCTION OF NATURAL AND RECREATIONAL LAND
P6: WATER POLLUTION
C1: CYCLE 1 – "P9: RACIAL AND ECONOMIC SEGREGATION"
P25: INADEQUATE SOLID WASTE DISPOSAL
P5 AIR POLLUTION
P28 NEIGHBORHOOD DESTRUCTION BY FREEWAYS
P27: TRAFFIC NOISE AND FUMES
P24: ECONOMIC DEPENDENCE OF COMMUNITIES ON INDUSTRIES
P17: POLICY ACTION IMPOTENCE CAUSED BY DIFFUSION OF POLITICAL POWER

FIGURE IV-4: A PERCEPTION OF URBAN PROBLEM LINKAGES USING THE RELATION "AGGRAVATES": HIERARCHICAL COMPONENTS

Step 4: Analysis of Conditions

The intent of this step is to analyze the causal factors that have conditioned the direction and magnitude of the trends described in Step 3.

Because we identified in Step 1 three ekistic elements as being of primary importance in the metropolitan case, the teacher can focus on these three elements. The students might be asked to do some independent reading on the kind of metropolitan growth planning being practiced by various agencies in their particular region. After completing their independent work the class could use the Nominal Group Technique to generate a list of elements relevant to each one of the three primary sectors, as shown in Table IV-8.

Following a discussion of the element set, the class can perform an ISM exercise to develop a structure of the causal linkages among the elements. An exemplary structure is shown in Figure IV-5. The structure of Figure IV-5 contains three separate cycles; the elements belonging to these cycles are shown in Table IV-9. It is interesting to note that in addition to the hierarchical relationship displayed in Figure IV-5, the two major cycles, C_1 and C_2, display two important clusters among variables. Cycle C_1, for example, collects variables from the elements corresponding to Society and Networks and groups them together into what might be called a subsystem corresponding to the "economic base" of the metropolis. To the extent that the economic health of the region creates more leisure time for the citizens, they may be able to devote time and energy to civic activities in response to perceived and measured indicators of community viability. This type of activity is captured in Cycle C_2, which might be termed a "Metropolitan Consciousness Subsystem." The third cycle is a conceptually trivial one, consisting of only two elements.

TABLE IV-8: ELEMENTS CONTRIBUTING TO PRESENT TRENDS (IDENTIFIED BY SECTOR)

Socioeconomic Sector (Society):

R_1. Population (P).
R_2. Basic employment (number of manufacturing jobs).
R_3. Service employment (number of service-related jobs).
R_4. Gross regional product (GRP) (or per capita income).
R_5. Social commitment or identification with the metropolis (community spirit).
R_6. Technological factors (TF).
R_7. Leisure time (LT)

Land Use/Transportation Sector (Networks)

R_8. Average travel time from home to work trip (minutes).
R_9. Average travel time from home to shop trip (minutes).
R_{10}. Quality of rapid transit.
R_{11}. Average residential densities (people/square mile).
R_{12}. Number and location of power plants.
R_{13}. Percent of metropolitan area assigned to public open space.
R_{14}. Number of vehicles on the road/working day.
R_{15}. Extent of telecommunication-based services.
R_{16}. Per capita travel (PCT) (Intercity travel miles/person/year).

Ecological Sector (Nature)

R_{17}. Total air pollutant emissions (EE).
R_{18}. Air pollution index (API).
R_{19}. Industrial water discharges (ID).
R_{20}. Sewage discharges (SD).
R_{21}. Extent of use of disposal containers (DC).
R_{22}. Extent of recycling of materials (R).
R_{23}. Water pollution index (WPI).
R_{24}. Solid wastes index (SWI).
R_{25}. Noise pollution index (NPI).
R_{26}. Environmental quality index (EQI).

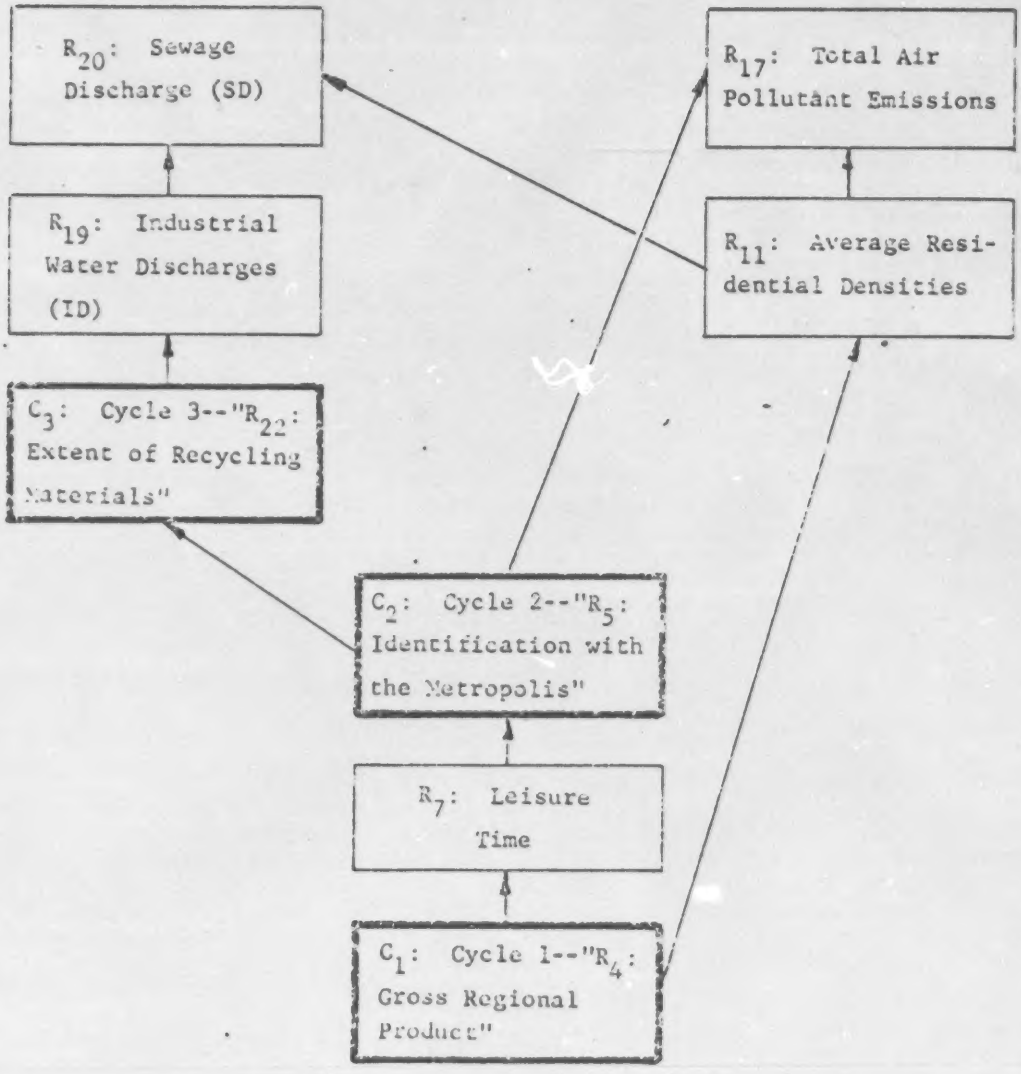

R_{20}: Sewage Discharge (SD)
R_{17}: Total Air Pollutant Emissions
R_{19}: Industrial Water Discharges (ID)
R_{11}: Average Residential Densities
C_3: Cycle 3--"R_{22}: Extent of Recycling Materials"
C_2: Cycle 2--"R_5: Identification with the Metropolis"
R_7: Leisure Time
C_1: Cycle 1--"R_4: Gross Regional Product"

FIGURE IV-5: REALITY STRUCTURE IDENTIFICATION: HIERARCHICAL COMPONENTS. THE RELATION IS "CAUSES OR AFFECTS".

TABLE IV-9: REALITY STRUCTURE IDENTIFICATION: CYCLIC COMPONENTS

Cycle C_1:

Generating Element:

R_4. Gross regional product (GRP) (or per capita income).

Remaining Elements:

R_1. Population (P).
R_2. Basic employment (number of manufacturing jobs).
R_3. Service employment (number of service-related jobs).
R_6. Technological factors (TF).
R_8. Average travel time from home to work trip (minutes)
R_9. Average travel time from home to shop trip (minutes).
R_{10}. Quality of rapid transit.
R_{12}. Number and location of power plant(s)
R_{14}. Number of vehicles on the road/working day.
R_{15}. Extent of telecommunication-based services.
R_{16}. Per capita travel (PCT) (Intercity travel/miles/person/year).

Cycle C_2:

Generating Element:

R_5. Social commitment or identification with the metropolis (community spirit).

RemainingElements:

R_{13}. Percent of metropolitan area assigned to public open space.
R_{18}. Air pollution index (API).
R_{23}. Water pollution index (WPI).
R_{24}. Solid wastes index (SWI).
R_{25}. Noise pollution index (NPI).
R_{26}. Environmental quality index (EQI).

Cycle C_3:

Generating Element:

R_{22}. Extent of recycling of materials (R).

Remaining Element:

R_{21}. Extent of use of disposal containers (DC).

Step 5: Invention, Evaluation, and Selection of Alternatives

In this step the class needs to search for policy interventions that will increase the probability of achieving the goals stated in Step 1. Again, the teacher can use an NGT to generate a set of policy initiatives similar to those identified in Table IV-10.

Following the NGT, an ISM exercise can be performed using the relation ". . . supports . . ." The resulting structure will indicate the degree of interaction among the various policy instruments, perhaps identifying "bundles" of policies which are mutually reinforcing.

Following the completion of Steps 1 through 5, the class, with the help of the teacher acting as a facilitator, should try to generate an overall synthesis that could then be documented by one or two students acting in the role of group rapporteurs.

TABLE IV-10: IDENTIFICATION OF POLICY INITIATIVES FOR IMPROVING THE ENVIRONMENTAL QUALITY INDEX OF A METROPOLIS

P_1. Reduced taxes on low-emission fuels.
P_2. Development of efficient public transportation system.
P_3. Introduction of bus lanes on urban highways to encourage public transportation and car pooling.
P_4. Staggered work hours and four-day work weeks.
P_5. Charge for total effluent discharges, encouraging recycling in industries and conservation at home.
P_6. Charge for discharge of untreated wastes into waterways.
P_7. Diversion of aircraft flight patterns from residential neighborhoods.
P_8. Construction of landscaped or other buffer zones along all major highways.
P_9. Government subsidy for using recyclable containers.
P_{10}. A levy on total quantities of trash and solid wastes generated.
P_{11}. Introduction of new technology for recycling of solid wastes.

CONCLUSIONS

By means of the two examples presented in this Chapter we have tried to demonstrate the meaningfulness and utility of studying human settlements through the use of the collective inquiry techniques discussed in Chapter III. The learning approach advocated in both of the cases emphasizes the response of the learners. In this type of a learning atmosphere the teacher serves the role of the discussion leader and moderator instead of the teacher being perceived as the "archive of knowledge".

The introduction of the Ekistics framework, together with the policy perspective, helps students to organize their knowledge and experiences on human settlement phenomena. The system for inquiry approach encourages the students and the teacher to do more than just "examine the facts". They are invited to generate ideas regarding their perceptions of a problem situation, to structure these ideas and present them graphically, and to explore the type of human actions or policies that would contribute to the resolution of the problem situation.

By basing the inquiry approach to the study of human settlements on systems and futures-oriented thinking we are helping students understand the complex nature of societal problems, and to appreciate the role of the human agent in terms of inventing policies for problem resolution.

Additional examples, similar to those discussed in this report, will need to be worked out in order to better demonstrate and communicate the utility of the approach. In addition to such techniques as ISM and NGT, other methods will need to be designed in a way that they can be easily implemented by high school educators.

CHAPTER V

A SYSTEMIC ASSESSMENT AND APPLICATION OF THE EKISTICS TYPOLOGY

INTRODUCTION

After we applied the systems of inquiry to two illustrative cases, it appeared desirable to investigate the degree to which the Ekistics taxonomy as used in Chapter IV captures the "universe of discourse" of the field of Environmental Education. In order to obtain some information regarding this issue, we chose to analyse a sample of papers published by scholars and practitioners of EE in the Journal of Environmental Education.

Existing organizations of knowledge are largely the result of evolution, rather than of careful analysis and synthesis.(1) Such knowledge organizations can be tolerated when they are insufficiently developed because they contribute to broader purposes than their own construction. When it is necessary to assimilate knowledge across organizational structures, it becomes important to structure knowledge through careful analysis and synthesis.

The state of evolution of a field of knowledge can be identified by means of a library literature survey. Index terms (key words) provided in publications in the field can be used in the categorization of literature in the library. In a given paper, index terms as a group should optimally characterize the paper. Index terms do not have any standardized terminology and thus they fail to furnish the essence of the papers in many cases. For example, one paper starts with. . . This paper is neither about biology nor about anthropology, but about general systems thinking and how it was used to bridge the gap between well developed models in one field (biology) and a new model in the other (anthropology) . . . and the "index terms" given are 'adaptation', 'hierarchy', 'cultural

anthropology', 'inheritance' . . . To diminish this conceptual confusion, some sort of analysis of organizations of knowledge would be beneficial.

In the last three decades, several organizations of knowledge have emerged and are trying to establish themselves as separate disciplines. In some cases, various branches of a particular knowledge organization are evolving spontaneously and individually, without any significant coordination. No specific contents of the theory are given. An example is given for general systems theory.

What is general systems theory? What are the contents of this theory? Many experts in the field have defined general systems theory in different ways. Unfortunately, a careful analysis of the contents of the general systems theory does not exist in the present literature. According to Klir,(2) "general systems theory in the broadest sense refers to a collection of general concepts, principles, tools, problems, methods and techniques associated with systems. Although the name 'system' may have different meanings under different circumstances and for different people, it ordinarily stands for an arrangement of certain components so interrelated as to form a whole. Diverse types of components and their interrelations represent different systems." What are these concepts, principles, tools and techniques?

One way to know about general systems theory is to analyze the research work which has been done in this area. A first effort involved a content analysis of several issues of the International Journal of General Systems in an attempt to separate the content into an array of relatively independent subjects. This study provided a structure for general systems theory.

It was found that the issues of the Journal that were examined could be described using six broad descriptors: mathematical theory, philosophical theory, systems theory, systems methodology, social theory and general theory. Each of these broad descriptors could be further categorized to lend specificity. Elaboration appears in [3].

Ekistics has been proposed by C. A. Doxiadis in an attempt to develop a science for human settlements.(4) His rationale is based on the realization that human settlements are complex systems requiring the application of knowledge from many disciplines properly organized and integrated under the rubric of one science, namely Ekistics.

The Ekistics Journal has attempted to establish a standardized terminology for the categorization of papers in the Journal. Analysis of the ekistics typology (the one used in the Ekistics Journal) is discussed later on in this chapter.

STANDARD EKISTICS TYPOLOGY

The articles in the Ekistics Journal are coded by the scale of a human settlement and an aspect as represented by a particular ekistic element. The content of each article is classified within the ekistics grid as follows:

- The scale of the settlement(s) relevant to the article is selected from among 15 ekistics units, such as:

Anthropos	1
Room	2
.	
.	
.	
Ecumenopolis	50,000 million

- A tree-like categorization of ekistics, as used in the Ekistics Journal, is represented by the hierarchy shown in Figure V-1. The phenomena dealt with in each article are selected from among the subheads of the five ekistics elements: Nature, Anthropos, Society, Shells and Networks (see Figure V-1). Contents of each article are presented

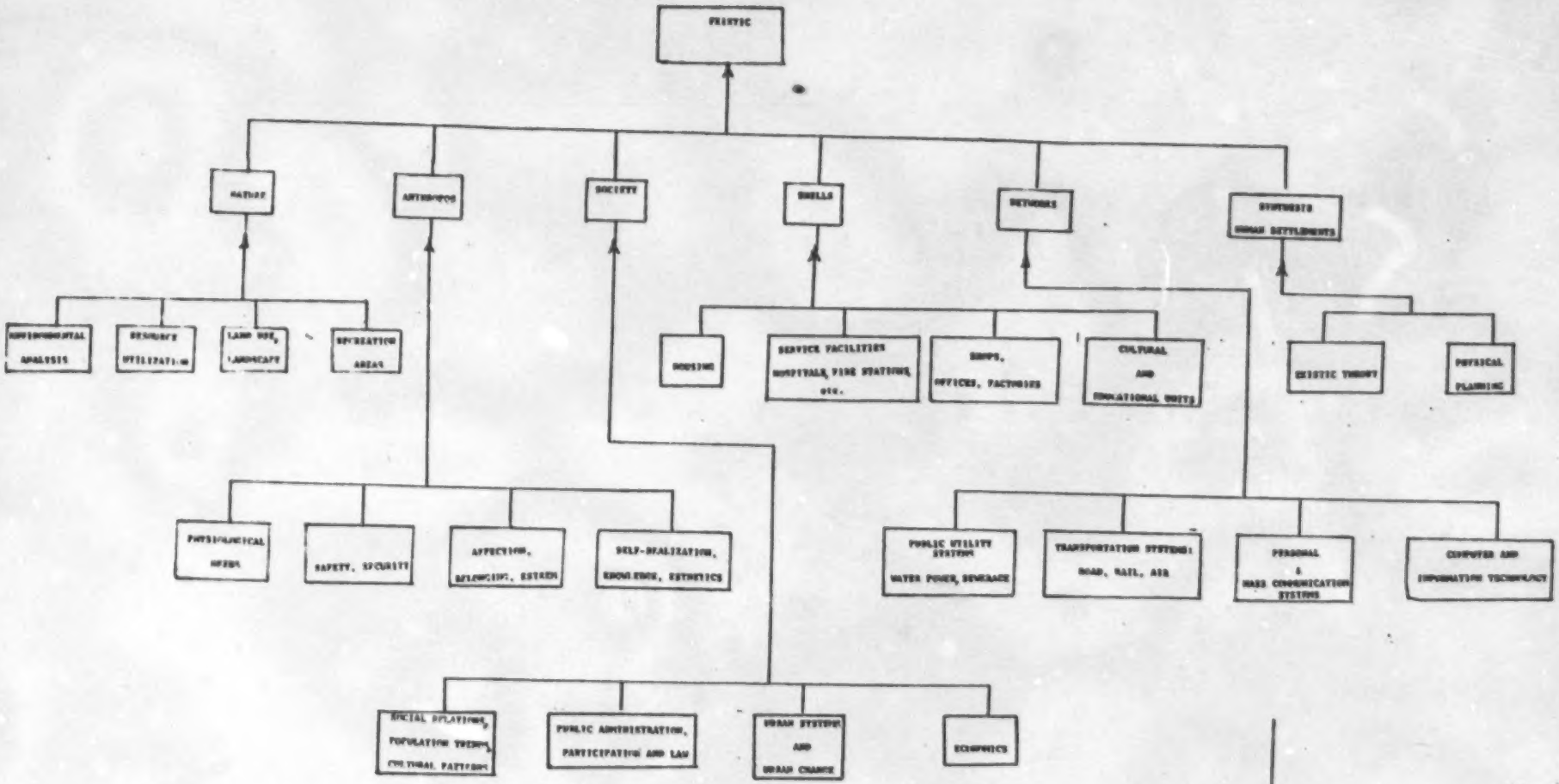


Figure V-1. A Hierarchy for Ekistics

graphically in the ekistics grid by identifying the ekistics elements and the scale of settlements addressed. Synthesis of these elements is also represented in the ekistics grid.

Critique of the Typology

This approach for graphic representation of the content of an article assumes an "idealized" reader (or subscriber to Ekistics Journal) who can at a glance visually determine his or her interest in the materials presented in the particular article. It is suggested that very few Ekistics Journal readers develop adequate sensitivity to the ekistics grid so that by scanning the graphic representation they can make a meaningful interpretation of the categorization as performed unilaterally by the editor of the Ekistics Journal.

Ekistics is sub-divided up to a third level in the hierarchy shown in Figure V-1. It appears that some of the elements at the third level include several concepts, which make the ekistics grid non-translatable*. Consider an element at the third level 'transportation systems: road, rail, air'. If this element is given in the ekistics grid for an article, it does not say which particular transportation system(s) is covered in the article.

* The substantive complexity of a complex system or issue can be diminished by the introduction of structural complexity to describe that system or issue. No new complexities should be introduced as a consequence of the graphics, other than those that have been shown to be inseparable from the graphics. A graphic is translatable if it can be converted unambiguously into prose. See [1] for a detailed discussion.

FORMULATION OF A TYPOLOGY

In this section we will briefly describe a method to develop a typology for a knowledge organization. For this, we define the following:

ELEMENT: A concept which is necessary to describe the essence of a field of a knowledge organization. It may not be sufficient.

SET OF ELEMENTS: A collection of elements which is sufficient to describe the universe of discourse of the knowledge organization.(5)

Let us refer to the set of elements comprised in such a universe of discourse, as the set D. Now, if our typology contains a classificatory or categorical concept M_i (i=1,2,3,...N), applicable to some but not all the members of D, then, by employing M_1 we may divide D into N subsets. Let N be equal to 2. Then we may divide D into two subsets: one containing each member of D that M_1 is true of, or applies to, and one containing each member of D that M_1 is not true of or M_2 is true of. Also, elements (or members) of categorical concepts can themselves be categorical concepts. A transitive relation R is also identified (such as an inclusion relation) that determines an ordering among categorical concepts and their members.

Let D = a knowledge organization

$$D = \{D_1, D_2, D_3, D_4, D_5, D_6\}$$

M_1, M_2 and D_2 are three categorical concepts.

The hierarchy for D is shown in Figure V-2.

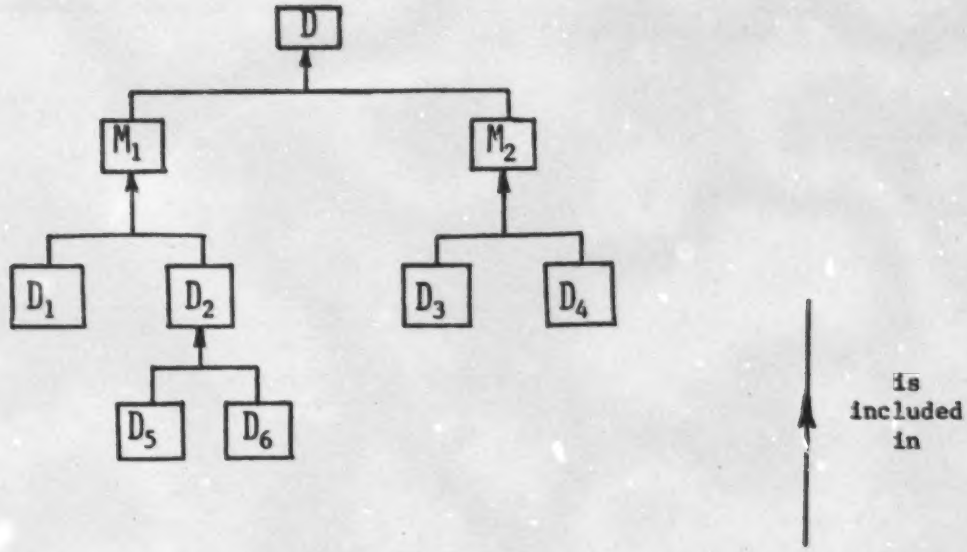


Figure V-2. Hierarchy for D

In summary, a typological system should contain at least the following:

a. A concept determining the typology's universe of discourse (e.g. human settlements)

b. A set of elements for the typology's universe of discourse

c. Some categorical concepts

d. A transitive relation R (e.g. an inclusion relation) that determines an ordering among categorical concepts and their elements

e. A graphic used to present the contents of an article that is translatable

Deriving an Ekistics Typology

In accordance with the discussion above on formulating typologies, we embarked on the derivation of an ekistics typology by analyzing the contents of the following two references:

(1) C. A. Doxiadis' book titled "Anthropolis"[6] and

(2) A report by the Stanford Research Institute, funded by the National Science Foundation, titled "City Size and the Quality of Life."[7]

Both these references address aspects of human settlements. We are making the assumption that the above two references exhaust the universe of discourse. After a content analysis of the two references, we extracted the most important concepts as listed in Tables V-1 and V-2.

The concepts can be organized in different ways to develop one or more hierarchical structures. An alternative approach is to analyze the standard ekistic typology as displayed in Figure V-1 in the light of the extracted concepts and then modify the typology if necessary. This approach leads to the following observations based on the use of the transitive relation "is included in" as shown in Figure V-1.

Table V-1

Concepts Extracted from C. A. Doxiadis' book titled "Anthropolis" [6]

	CONCEPT		CONCEPT
1.	Human Cities	33.	Human Contacts
2.	Human Development	34.	Creativity
3.	Soil, Air, Food, Water, Trees, Houses	35.	Garden
4.	Contacts with Social Groups	36.	Neighbors
5.	Protective Space	37.	Courtyard
6.	Safety and Happiness	38.	Home Streets
7.	Human Life	39.	Transportation
8.	Villages	40.	Schools, College, University
9.	Urban Systems	41.	Car, Airplane
10.	Design of Rooms	42.	Health
11.	Urban Change	43.	Shopping Centers
12.	Transportation	44.	Physiological Needs
13.	City Change and Growth	45.	Land Use
14.	Pollution	46.	Complexity
15.	Quality of Life	47.	Intolerant of Boredom
16.	Population	48.	Generation Gap
17.	Noise	49.	Ecology
18.	Energy	50.	Perception
19.	Population Growth	51.	Animals
20.	Waste Water, Sewers	52.	Monumental Buildings
21.	Economy	53.	Segregated Communities (by age group
22.	Society	54.	Character of Work Places
23.	Culture	55.	Density
24.	Crime	56.	Communication
25.	Social Interaction	57.	Biological Heritage
26.	Factories	58.	Psychological Heritage
27.	Senses, Mind, Soul	59.	Language
28.	Cultural Groups, Ethnic, Racial	60.	Work Place
29.	Physical Environment of the City	61.	Easy Access to Nature
30.	Environmental Problems	62.	Social Separation
31.	Employment	63.	15 Ekistics Units
32.	Plants	64.	12 Phases of Life

Table V-2

Concepts Extracted from The Stanford Research Institute Report [7]

	CONCEPT		CONCEPT
1.	City Size	33.	Food Crisis
2.	Quality of Life	34.	Population Distribution
3.	Urbanization	35.	Security
4.	Metropolitan Areas	36.	Survival
5.	Population	37.	Human Life
6.	Urban Problems	38.	Social-psychological Attributes
7.	Congestion	39.	Race
8.	Pollution	40.	Income
9.	Health	41.	Alcoholism
10.	Crime	42.	Migration
11.	Loss of Community	43.	Water
12.	Government Fragmentations	44.	Parks, Trees
13.	Urban Growth	45.	Air
14.	Land Use Programs	46.	Cultural Diversity
15.	Economic Growth	47.	Social Pathology
16.	Geographic Distribution	48.	Technology
17.	Population Growth	49.	Transportation
18.	Population Balance	50.	Communication
19.	Cultural Opportunities	51.	Politics
20.	Life-styles	52.	Ecology
21.	Resources	53.	Welfare
22.	Complexity	54.	Democracy
23.	Environmental Quality	55.	Industry
24.	Air Pollution	56.	Universities
25.	Noise Pollution	57.	Racial Problems
26.	Traffic Deaths	58.	Drugs
27.	Waste Treatment	59.	Violence
28.	Sewer Systems	60.	Technology
29.	Employment	61.	Economics
30.	Economic Forces	62.	Medicine
31.	Institutions	63.	Agriculture
32.	Energy	64.	Mining

- A careful analysis of the standard ekistics typology and the concepts given in Tables V-1 and V-2 shows that the typology covers most of the concepts directly and some implicitly. On the other hand, there are a few elements in the ekistics typology which, although not explicitly listed in Tables V-1 and V-2, appear to be implicitly included in [6] and [7]. Only the "phases of anthropos life" are not covered in the ekistics typology. Concepts such as factories and population included in Tables V-1 and V-2 are explicitly covered in the ekistics typology, while such concepts as air pollution and water pollution seem to be covered implicitly by the subheading "environmental analysis" shown in Figure V-1 as linked to the ekistic element "Nature."
- Previously we said that the graphics used in the Ekistics Journal are non-translatable. The graphics can be made translatable by extending the 3-level ekistics tree (Figure V-1) to a 4-level tree, for example, a third level element 'environmental analysis' can be categorized as shown in Figure V-3.

If we choose to compromise between extreme generality and extreme detail or specificity, it appears that the standard ekistic typology is useful and meaningful for the construction of a science of human settlements. In other words, on the basis of our systemic assessment of the ekistics typology, we conclude that the classical typology used in the Ekistics Journal is acceptable. However, it is still an open question whether or not 'phases of anthropos life' should be introduced as a distinct concept in the typology.

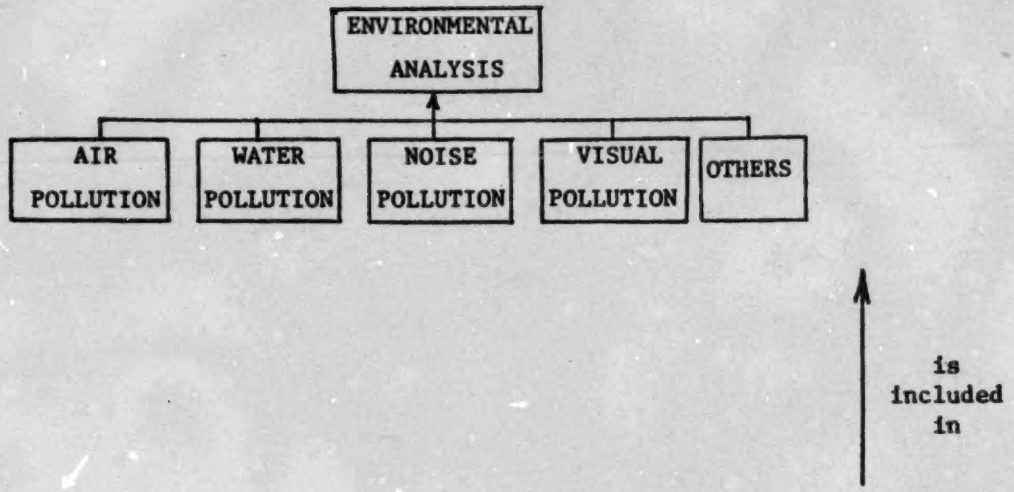


Figure V-3. Hierarchy for a Third Level Element "Environmental Analysis"

ENVIRONMENTAL EDUCATION

Though environmental education (EE) has been in existence for a number of years, people continue to debate what environmental education is and/or should be. The Environmental Education Act of 1970 defined environmental education to mean "the educational process dealing with man's relationship with his natural and manmade surroundings, and includes the relation of population, pollution, resource allocation and depletion, conservation, transportation, technology and urban and rural planning to the total human environment."

While the Environmental Education Act gave a definition for environmental education, it needed elaboration to put it in the context of education. For this purpose a study [8] was carried out to create a normative model (also called 'Big Map' in [8]) to display graphically what concepts should be included, according to educators, legislators and researchers, in the domain of education dealing with environmental issues.

The big map of EE is discussed in [8] and in Volume 3 of this report. Elements (about 160) for the model came from [9], [10], the EE Act, and products of grants sponsored by the Office of Environmental Education, HEW. The relation used to structure the elements was "should help achieve." The large number of elements led to a big normative model (given in [8]). This model can be visualized as seven subsets of related elements.

1. Planning lies at the base of the map and sets into motion the development of core themes, funding and institutional support.
2. Learning Systems Design is largely concerned with developing and modifying curricula and community education approaches to meet environmental education objectives.
3. Personnel Development provides for training of teachers and community education facilitators.
4. Learning Activities is the actual conduct of programs laid out in Learning Systems Design.
5. Learning Outcomes is the realization of the various environmental education goals set forth in the Act and elsewhere.
6. Delivery Systems and Support includes activities that will institutionalize environmental education and provide for dissemination of newly developed materials and approaches.
7. Evaluation, like delivery systems and support, is a continuing set of activities that intermesh with the first five subsets.

The structure for the seven subsets is given in Figure V-4 and this represents the educational domain. Detailed structures for each subset are given in [8]. Figure V-5 shows the detail of one of the seven subsets, 'Learning Outcomes'.

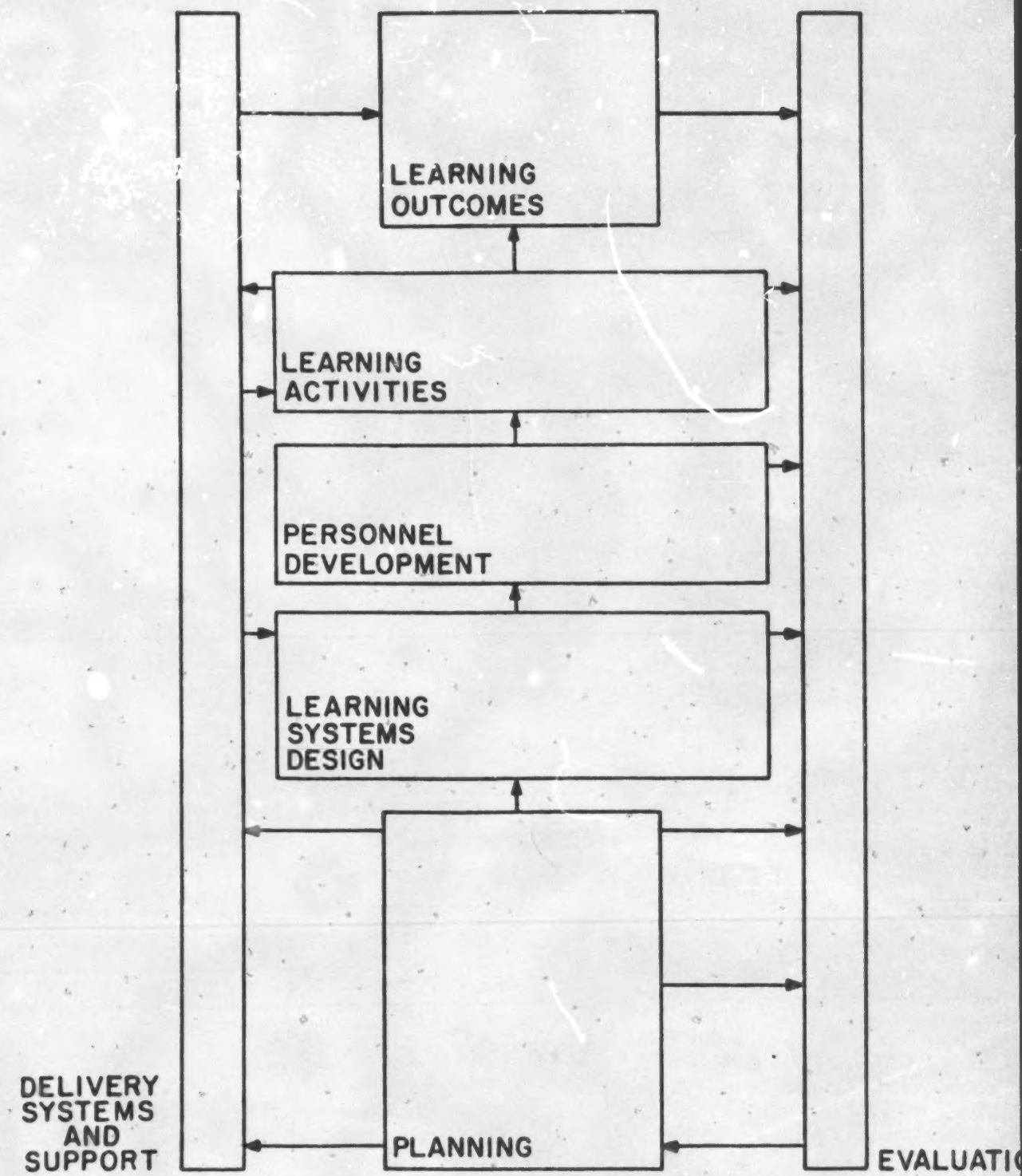


Figure V-4. Schematic of Normative Model Showing Superstructure

(The arrow represents "should help achieve")

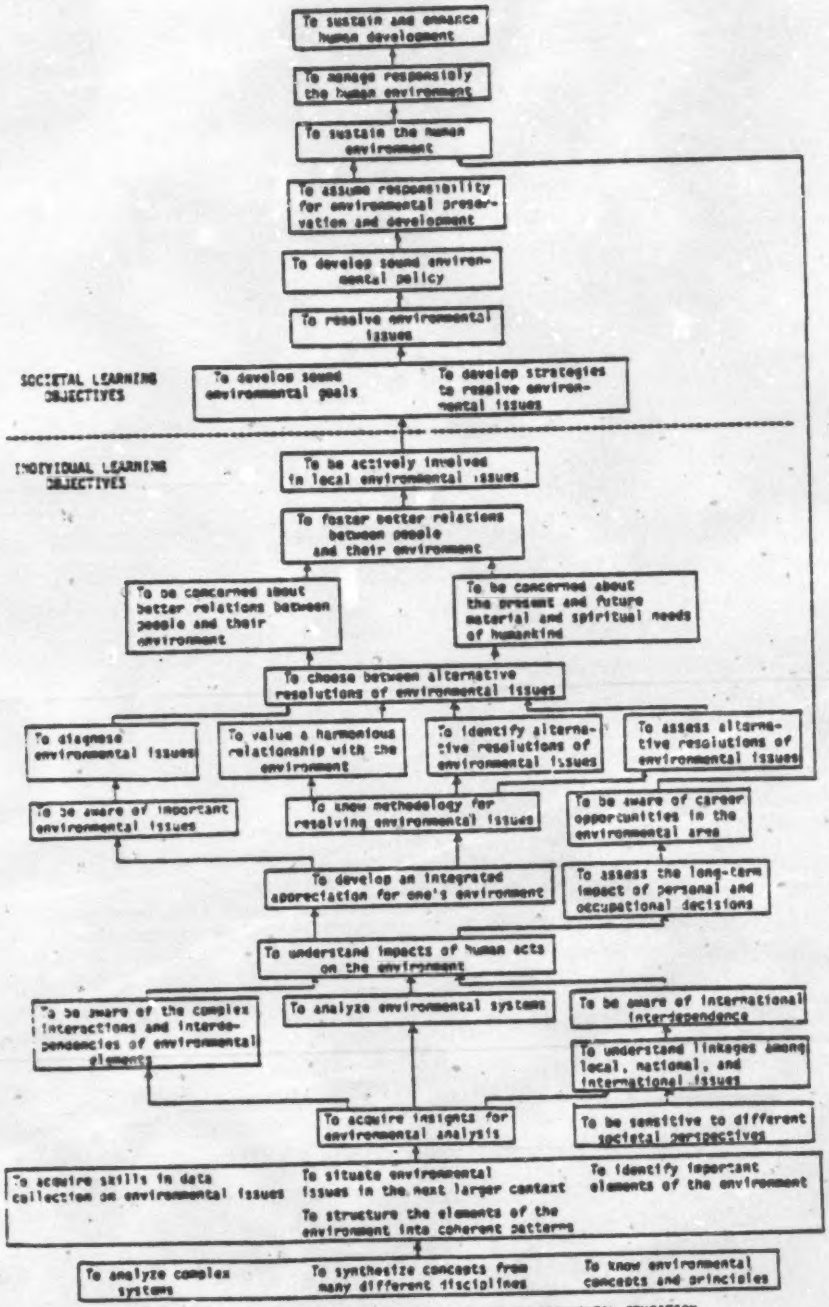

To sustain and enhance human development
To manage responsibly the human environment
To sustain the human environment
To assume responsibility for environmental preservation and development
To develop sound environmental policy
To resolve environmental issues
SOCIETAL LEARNING OBJECTIVES
To develop sound environmental goals
To develop strategies to resolve environmental issues
INDIVIDUAL LEARNING OBJECTIVES
To be actively involved in local environmental issues
To foster better relations between people and their environment
To be concerned about better relations between people and their environment
To be concerned about the present and future material and spiritual needs of humankind
To choose between alternative resolutions of environmental issues
To diagnose environmental issues
To value a harmonious relationship with the environment
To identify alternative resolutions of environmental issues
To assess alternative resolutions of environmental issues
To be aware of important environmental issues
To know methodology for resolving environmental issues
To be aware of career opportunities in the environmental area
To develop an integrated appreciation for one's environment
To assess the long-term impact of personal and occupational decisions
To understand impacts of human acts on the environment
To be aware of the complex interactions and interdependencies of environmental elements
To analyze environmental systems
To be aware of international interdependence
To understand linkages among local, national, and international issues
To acquire insights for environmental analysis
To be sensitive to different societal perspectives
To acquire skills in data collection on environmental issues
To situate environmental issues in the next larger context
To structure the elements of the environment into coherent patterns
To identify important elements of the environment
To analyze complex systems
To synthesize concepts from many different disciplines
To know environmental concepts and principles

Fig. V-5, STRUCTURE OF LEARNING OUTCOMES FOR ENVIRONMENTAL EDUCATION
(A ⟶ B means ELEMENT A SHOULD HELP ACHIEVE ELEMENT B)

Environmental Education Typology

A careful literature survey shows that no typology exists for environmental education. A typology is desirable for the analysis of the existing literature and for planning the future evolution of this field. By using the procedure discussed earlier, a typology for environmental education can be constructed.

On the basis of our research and findings reported here we feel confident to impute that the universe of discourse for EE can be obtained by combining the superstructure of the big map with the ekistics typology. The rationale for proceeding in this fashion is based on the presupposition that the ideas encompassed by the superstructure are a good representation of the educational domain. On the other hand, the subject matter of environment, at least as it relates to human habitation, should be captured by the ekistics typology derived earlier.

Thus, we can say an EE typology consists of: (a) the environmental domain and (b) the educational domain. Graphically, the two domains are represented separately in Figures V-1 and V-6, respectively. In Figure V-6 we have transformed the superstructure representation into a tree, using the relationship "is included in," in order to make it symmetrical to the earlier transformation of the ekistics grid to an ekistics tree.

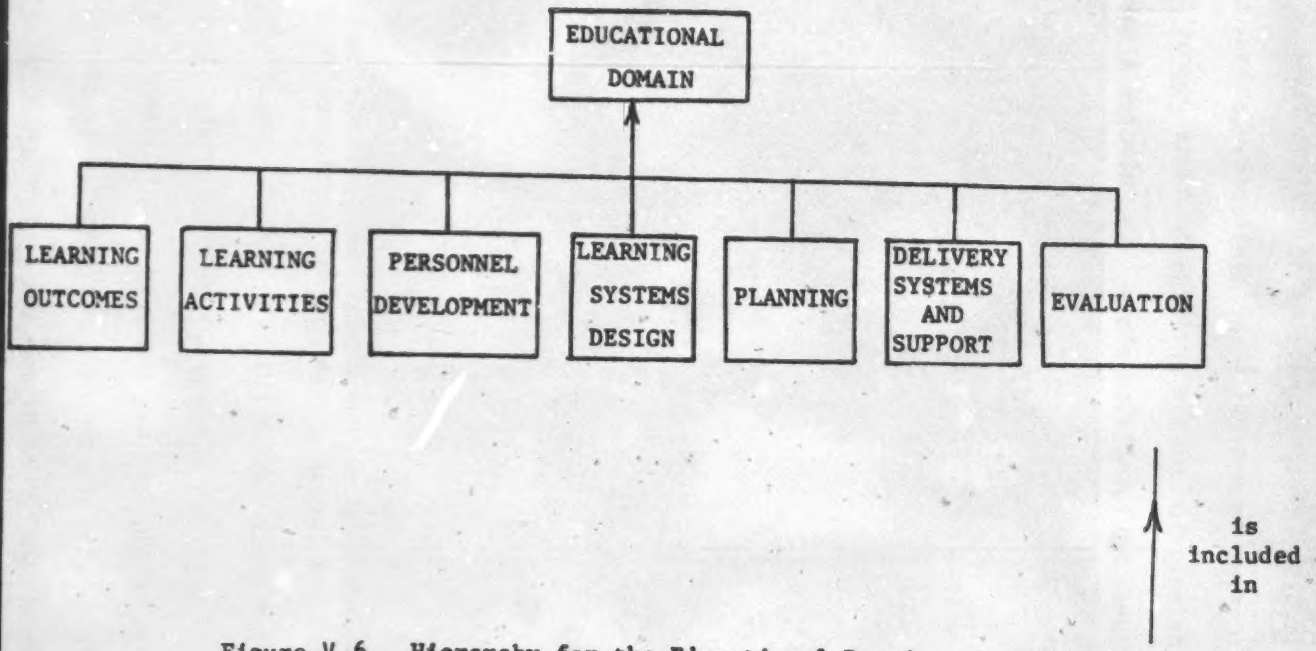


Figure V-6. Hierarchy for the Educational Domain

Application of Environmental Education Typology

This section discusses content-analyses of sixteen issues of The Journal of Environmental Education to determine the similarity between the conceptual and terminological orientation of the articles in these Journals and the universe of EE discourse as identified above. We selected a sample of issues of the Journal as specified in [11].

A careful content analysis of each paper was performed in order to identify the most important elements used in the paper. Contents of each paper were analyzed with respect to different elements of the 'environmental domain' and the 'educational domain' (Figures V-1 and V-6), and the relevant concepts were identified for the paper. Elements covered by each paper are presented in Table V-3. Each paper is represented by four numbers.

First number: Volume number of Journal of Environmental Education

Second number: Issue number of the volume

Third number: Year of publication of the Journal

Fourth number: Starting page number of the paper

For example, a paper represented by 9.4.1978.4 is from Volume 9, Number 4 of the year 1978 and it starts on page number 4.

We believe that the issues of the Journal considered in this study are representative of the research published in all issues of The Journal of Environmental Education. It appears from our research that a majority of papers in the issues of the Journal analysed cover elements falling in the 'educational domain'. It is suggested that more papers should be published to cover the 'environmental domain' for the Journal of Environmental Education to be representative of the organization of EE knowledge recommended in this report.

Table V-3

Analysis of Papers Published in
Journal of Environmental Education [11]

Paper Number	Element(s)	Paper Number	Element(s)
5.1.1973. 1	Planning	5.3.1974. 1	Evaluation
5.1.1973. 4	Planning, Environmental Analysis	5.3.1974. 8	Evaluation
		5.3.1974.12	Learning Systems Design
5.1.1973. 8	Planning, Environmental Analysis	5.3.1974.15	Learning Systems Design
		5.3.1974.19	Personnel Development, Learning Systems Design
5.1.1973.12	Planning, Recreational Analysis	5.3.1974.24	Evaluation
5.1.1973.18	Planning	5.3.1974.27	Learning Systems Design
5.1.1973.21	Evaluation	5.3.1974.29	Evaluation, Learning Systems Design
5.1.1973.23	Evaluation		
5.1.1973.31	Planning, Communication	5.3.1974.33	Planning
		5.3.1974.37	Personnel Development
5.1.1973.37	Planning	5.3.1974.42	Learning Systems Design
5.1.1973.41	Planning, Ecology	5.3.1974.44	Cultural Ecology
5.1.1973.43	Planning	5.3.1974.47	Evaluation, Environmental Analysis
5.1.1973.45	Evaluation, Communication	5.3.1974.53	Economics
5.1.1973.51	Evaluation, Communication	5.3.1974.56	Learning Systems Design
		5.3.1974.58	Learning Systems Design
5.1.1973.58	Communication	5.3.1974.61	Planning
5.2.1973. 1	Planning	5.4.1974. 1	Delivery Systems and Support
5.2.1973. 4	Learning Systems Design	5.4.1974. 4	Learning Systems Design
		5.4.1974. 8	Communication
5.2.1973. 5	Evaluation	5.4.1974.14	Evaluation
5.2.1973. 9	Evaluation	5.4.1974.19	Learning Systems Design
5.2.1973.13	Learning Systems Design	5.4.1974.21	Evaluation
5.2.1973.20	Learning Systems Design	5.4.1974.25	Learning Systems Design
5.2.1973.23	Ecology, Diversity	5.4.1974.29	Evaluation, Attitude
5.2.1973.28	Evaluation	5.4.1974.31	Evaluation, Learning Systems Design
5.2.1973.31	Learning Systems Design		
5.2.1973.33	Learning Systems Design	5.4.1974.34	Evaluation
5.2.1973.35	Learning Systems Design	5.4.1974.37	Population, Evaluation
5.2.1973.38	Planning	5.4.1974.42	Evaluation
5.2.1973.40	Planning	5.4.1974.46	Learning Systems Design
5.2.1973.43	Evaluation	5.4.1974.48	Planning, Learning Systems Design
5.2.1973.49	Attitude		
5.2.1973.52	Evaluation	5.4.1974.54	Evaluation, Attitude
5.2.1973.61	Learning Systems Design		

Table V-3 (cont.)

Paper Number	Element(s)
7.2.1975. 2	Economics
7.2.1975. 9	Evaluation
7.2.1975.11	Planning, Learning Systems Design
7.2.1975.21	Evaluation
7.2.1975.27	Learning Systems Design
7.2.1975.32	Social Ecology
7.2.1975.44	Learning Systems Design, Wild Food
7.2.1975.48	Evaluation
7.2.1975.54	Recycling, Evaluation, Learning Systems Design
7.2.1975.59	Evaluation
7.3.1976. 2	Learning Systems Design
7.3.1976.11	Economics
7.3.1976.20	Environmental Quality, Evolutionary Theory
7.3.1976.28	Ecology
7.3.1976.34	Evaluation
7.3.1976.38	Evaluation
7.3.1976.51	Evaluation
7.3.1976.61	Evaluation
7.3.1976.66	Behavior Objectives, Evaluation
8.1.1976. 2	Ecology
8.1.1976.10	Evaluation, Knowledge, Attitude
8.1.1976.19	Evaluation
8.1.1976.26	Evaluation, Value Judgment
8.1.1976.32	Evaluation
8.1.1976.36	Evaluation
8.1.1976.48	Evaluation, Attitude
8.1.1976.52	Evaluation
8.2.1976. 2	Planning
8.2.1976.12	Evaluation
8.2.1976.19	Planning
8.2.1976.26	Evaluation
8.2.1976.37	Evaluation
8.2.1976.41	Learning Systems Design
8.2.1976.52	Learning Systems Design
8.2.1976.60	Oral History
8.3.1977. 4	Planning
8.4.1977. 7	Planning
8.3.1977.11	Learning Systems Design, Personnel Development
8.3.1977.17	Land Use, Planning, Learning Systems Design
8.3.1977.26	Evaluation
8.3.1977.32	Evaluation
8.3.1977.40	Planning, Personnel Development
8.3.1977.48	Learning Systems Design, Computer
8.3.1977.54	Learning Systems Design
8.3.1977.60	Mass Communication
8.4.1977. 4	Psychology
8.4.1977. 8	Learning Systems Design, Energy
8.4.1977.18	Evaluation
8.4.1977.27	Evaluation
8.4.1977.35	Planning, Evaluation, Population
8.4.1977.43	Population, Evaluation
8.4.1977.57	Evaluation
9.1.1977. 4	Planning
9.1.1977.23	Evaluation, Recreation
9.1.1977.31	Evaluation
9.1.1977.44	Evaluation
9.1.1977.50	Evaluation

Table V-3 (cont.)

Paper Number	Element(s)
9.2.1978. 5	Value Judgment, Learning Systems Design
9.2.1978.18	Food
9.2.1978.20	Evaluation
9.2.1978.24	Evaluation
9.2.1978.37	Planning, Learning Systems Design
9.2.1978.49	Evaluation, Attitude
9.3.1978. 2	Evaluation
9.3.1978.12	Evaluation
9.3.1978.18	Evaluation, Planning
9.3.1978.28	Evaluation
9.3.1978.35	Economics
9.3.1978.40	Evaluation
9.3.1978.50	Evaluation
9.3.1978.58	Planning
9.4.1978. 4	Knowledge
9.4.1978.10	Evaluation
9.4.1978.20	Evaluation
9.4.1978.30	Evaluation
9.4.1978.36	Evaluation
9.4.1978.41	Attitude, Knowledge, Evaluation
9.4.1978.51	Evaluation
9.4.1978.55	Value Judgment
10.1.1978. 2	Evaluation
10.1.1978.12	Evaluation
10.1.1978.16	Learning Systems Design
10.1.1978.19	Learning Systems Design
10.1.1978.23	Evaluation
10.1.1978.32	Evaluation
10.1.1978.35	Values, Evaluation
10.1.1978.41	Evaluation
10.1.1978.44	Planning
10.2.1978. 3	Delivery Systems and Support
10.2.1978. 7	Evaluation, Value Judgment
10.2.1978.12	Evaluation
10.2.1978.18	Evaluation
10.2.1978.24	Planning
10.2.1978.30	Learning Systems Design, Value Judgment
10.2.1978.35	Evaluation
10.2.1978.43	Evaluation, Mass Communication Systems

CONCLUSIONS

In this chapter we undertook a study to explore the meaningfulness and viability of the standard ekistics typology by: (a) employing theoretical ideas about the use of typologies in the construction of social theory[5] and (b) reviewing a selected set of materials in the fields of human settlement phenomenology and environmental education.

A review of [6] and [7] was undertaken in order to extract the most significant concepts from these two publications. The standard ekistics typology was assessed, using a systemic approach and some comments are made for improvements of this typology.

A typology for environmental education is also proposed. Contents of sixteen issues of the Journal of Environmental Education were analyzed and a suggestion is made for improvement in the organization of this Journal in order for it to be more responsive to the proposed EE organization of knowledge.

REFERENCES

(1) J. N. Warfield, "Some Principles of Knowledge Organization," IEEE Trans. SMC, June 1979, 317-325.

(2) G. J. Klir, "The Polyphonic General Systems Theory" in: Trends in General Systems Theory, edited by G. J. Klir, John Wiley, New York, 1972. pp. 1-18.

(3) Virender Jain, "Structural Analyses of General Systems Theory," under review.

(4) C. A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlements, New York: Oxford University Press, 1968.

(5) R. S. Rudner, Philosophy of Social Science, Prentice-Hall, Inc., EnglewoodCliffs, N. J., 1966.

(6) C. A. Doxiadis, Anthropolis: City for Human Development, Athens Publishing Center, Athens, Greece, 1974.

(7) D. Elgin, T. Thomas, T. Logothetti, and S. Cox, "City Size and the Quality of Life." The Stanford Research Institute, NSF Contract G.I. 138462, November 1974.

(8) R. Fitz, J. Troha and L. Wallick, "An Integration of Normative Models for Environmental Education," University of Dayton, Dayton, OH, Contract 300-700-4029, June 1978.

(9) Center for Environmental Studies, Arizona State University and Association of American Geographers, "Environment-Based Environmental Education: Inventory, Analysis and Recommendations," Contract No. OEC-74-8739, June 30, 1975.

(10) "Education and The Challenge of Environmental Problems," UNESCO Report, Tbilisi, Russia, October 1977.

(11) The Journal of Environmental Education, Volume 5, Number 1, Fall 1973; Volume 5, Number 2, Winter 1973; Volume 5, Number 3 Spring 1974; Volume 5, Number 4, Summer 1974; Volume 7, Number 2, Winter 1975; Volume 7, Number 3, Spring 1976; Volume 8, Number 1, Fall 1976; Volume 8, Number 2, Winter 1976; Volume 8, Number 3, Spring 1977; Volume 8, Number 4, Summer 1977; Volume 9, Number 1, Fall 1977; Volume 9, Number 2, Winter 1978; Volume 9, Number 3, Spring 1978, Volume 9, Number 4, Summer 1978; Volume 10, Number 1, Fall 1978; Volume 10, Number 2, Winter 1978/1979.

APPENDIX A

SELECTED BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

Core Theme Research Materials

Banathy, Bela H., et. al., Resource Material Development: Development of Teacher Training Materials on Energy/Environmental Education and Design of a Program for Trainers, San Francisco, California: Far West Laboratory for Educational Research and Development, 1978.

Center for Environmental Studies, Environmental-Based Environmental Education: Inventory, Analysis, and Recommendations, Arizona State University, 1975.

Community Leadership Energy/Environmental Education Model. San Francisco, California: Far West Laboratory for Educational Research and Development.

Energy-Intensive Urban Growth and the Quality of Life. San Francisco, California: Far West Laboratory for Educational Research and Development.

Geography in an Urban Age: The High School Geography Project of the Association of American Geographers, New York: MacMillan Company, 1969.

Growth Implications and the Earth's Future: A Study of Curriculum Materials and Student Views, Newton, Mass.: Educational Development Center, Inc., 1976.

The High School Energy/Environmental Education Teacher Training Model, San Francisco, California: Far West Laboratory for Educational Research and Development.

The Natural Science Environmental Education Teacher Training Model, San Francisco, California: Far West Laboratory for Educational Research and Development.

The Social Science Environmental Education Teacher Training Model, San Francisco, California: Far West Laboratory for Educational Research and Development.

Riles, Wilson, The Guide for the Development of an Interdisciplinary Environmental Education, California State Departmentof Education, Sacramento, 1973.

Systems Approach

Banathy, Bela H., Developing a Systems View of Education -- the Systems Model Approach, Belmont, California: Fearon, 1973.

Buckley, Walter, Sociology and Modern System Theory, Englewood Cliffs, New Jersey: Prentice-Hall, 1973.

Churchman, C. West, The System Approach, New York: Dell Publishing Company, 1968.

Dewan, Edmond, Cybernetics and the Management of Large Systems, New York: Spartan Books, 1969.

Forrester, Jay W., Principles of Systems, Cambridge, Mass.: Wright-Allen Press, Inc., 1968.

Jantsch, Erich, "Inter- and Transdisciplinary University: A Systems Approach".

Laszlo, Ervin, The World System: Models, Norms, Variations, New York: George Braziller, 1973.

Warfield, John N., Societal Systems, New York: John Wiley & Sons, 1976.

Human Settlement (Ekistics)

Christakis, Alexander N., "Towards A Symbiotic Appreication of the Morphology of Human Settlements", in Portraits of Complexity, ed. Maynard M. Baldwin, Battelle Memorial Institute, 1975.

Cotton, Peter, Way, "Access to Cities for Teachers: Curriculum - Proof Kids Through Environmental Studies", American Collegiate Schools of Architecture Journal, 1973.

Doxiadis, Constantinos A., Ekistics: An Introduction to the Science of Human Settlements, New York: Oxford University Press, 1968.

Doxiadis, Constantinos A., Anthropolis: City for Human Development, Athens: Athens Publishing Center, 1974.

Doxiadis, Constantinos A., Ecumenopolis: The Inevitable City of the Future, Athens: Ahtens Publishing Center, 1974.

Eldredge, H. Wentworth, Taming Megalopolis; Volume I: What It Is and What Could Be, Garden City: Doubleday and Company Inc., New York, 1967.

Eldredge, H. Wentworth, Taming Megalopolis, Volume II: How to Manage on Urbanized World, Garden City: Doubleday and Company Inc., New York, 1967.

Geography in an Urban Age: The High School Geography Project of the Assocation of American Geographers, New York: MacMillan Company, 1969.

Havlick, Spenser W. The Urban Organism, New York: MacMillan Company, 1974.

Riles, Wilson, The Guide for the Development of an Interdisciplinary Environmental Education, California State Department of Education, Sacremento, 1973.

Futures

Fuller, R. Buckminster, Operations Manual for Spaceship Earth, Carbondale, Illinois: Southern Illinois University Press, 1969.

Cornish, Edward, The Study of the Future, Washington, D.C.: World Future Society, 1977.

Jantsch, Erich, Design for Evaluation, New York: George Braziller, 1975.

Kauffman, Drapper L., Teaching the Future, Palm Springs, Calif.: ETC Publications, 1976.

Kauffman, Drapper L., Futurism and Futures Studies, Washington, D.C., National Educational Association, 1976.

Laszlo, Ervin, A Strategy for the Future, New York: Harper and Row Publications, Inc., 1975.

Meadows, Donella; Meadows, Dennis; Randers, Jorgen; Behrens, William III, The Limits to Growth, New York: Signet Books, 1972.

Schumacher, E.F., Small is Beautiful, New York: Harper and Row Publications., Inc., 1975.

Skinner, B.F., Beyond Freedom and Dignity, New York: Bantam, 1971.

The Study of the Future: An Agenda for Research, National Science Foundation, Washington, D.C.: U.S. Government Printing Office, 1977.

Watt, Kenneth, The Relationship Between Resource Use and Economic Growth: Forces Determining the Future; Louisiana State University, 1976.

Watt, Kenneth, The Titanic Effect: Planning for the Unthinkable, Stamford, Connecticut: Sinauer, 1974.

Evaluation

Bloom, B.S., Hastings, F., Madaus, G.F., Handbook of Formative and Summative Evaluation of Student Learning, New York: McGraw-Hill, 1971.

Costa, Arthur L., "Strategies for Developing Autonomous Learners", Audiovisual Instruction, XIII, 832, October, 1968.

Far West Laboratory, Educational Management Program Series: Evaluation for Program Improvement, San Francisco, Calif.: Far West Laboratory for Educational Research and Development, 1975.

Popham, James W., Criterion-Referenced Measurement, Englewood Cliffs, New Jersey: Educational Technology Publications, 1971.

Popham, James W., The Teacher-Empiricist, Los Angeles, California: Aegeus Publishing Co,: 1965

Rippey, Robert M. Ed., Studies in Transactional Evaluation, Berkeley, Calfornia: McCutchan Publishing Corporation, 1973.

Policy Science

Brezina, Dennis W. and Overmyer, Allen, Congress in Action, New York, The Free Press, 1974.

Galbraith, John K., Economics and The Public Purpose, New York: New American Library, 1975.

Hammond, Allen; Metz, William; Maugh, Thomas III, Energy and The Future, Washington, D.C., American Association for the Advancement of Science, 1973.

Lasswell, Harold D., A Preview of Policy Science, New York: Elsevier, 1971.

APPENDIX A

SOME PRINCIPLES OF KNOWLEDGE ORGANIZATION

Removed due to copyright restrictions.

APPENDIX B

AN INTRODUCTION TO

ENVIRONMENTAL EDUCATION TEACHER TRAINING RESOURCES

APPENDIX B*

AN INTRODUCTION TO

ENVIRONMENTAL EDUCATION TEACHER TRAINING RESOURCES

The Far West Laboratory for Educational Research and Development, supported by the U. S. Office of Environmental Education, developed a set of environmental education teacher training resources with an energy-focused perspective. The design and development of these resources was based on a conception of environmental education that is consistent with the Environmental Education Act of 1970 (P.L. 91-516 and P.L. 93-278, as amended):

- o Environmental Education should be holistic and integrated... focusing on and clarifying the complex relationships existing between natural and human systems, and examining the many aspects and interdependencies of both.

- o Environmental Education should be interdisciplinary... utilizing information from a variety of fields or disciplines (including the natural sciences, social sciences, and humanities) in order to deal adequately with the natural, social, aesthetic, and ethical dimensions of environmental issues.

- o Environmental Education should emphasize problem-solving and decision-making... presenting learners with real environmental problems or issues that are broad enough in scope to have regional, national, or global significance. It should engage learners in values clarification, problem-solving, planning, and decision-making activities that prepare them for dealing with environmental problems and issues that affect individuals and society.

The resources developed are of two kinds: teacher-training models and teacher-training materials. The models are conceptual documents whose purposes are to describe the various dimensions and priorities of an environmental education teacher training program. The teacher-training materials are designed to be used in secondary preservice or inservice programs, continuing education programs, or utilized by small groups of teachers who wish to increase their understanding of and competence in dealing with energy and environmental issues in the classroom.

The Environmental Education Teacher-Training Models

Four Environmental Education Teacher Training models were developed, each targeted to a different group of educators: high school teachers, natural science teachers (grades K-9), social science teachers (grades 4-12), and community leaders (in environmental education).

Each model contains sections that define, characterize, or describe the following aspects of an environmental education teacher-training program: a rationale and definition of environmental education, general behavioral objectives, the curriculum content, general instructional management arrangements, and implementation processes and activities. Each of the four models was designed to address the following basic user concerns:

- o What general knowledge, skills, and attitudes am I to acquire?
- o What EE content do I need to know?
- o What instructional or learning arrangements are needed?
- o What physical and logistical arrangements are needed?

The Content Sourcebook.

The Content Sourcebook presents an elaborated and annotated discussion of the Content Specifications given in each of the models, and is intended to provide a more detailed understanding of the resources needed to develop a "holistic and transdisciplinary" environmental education curriculum.

The Content Sourcebook elaborates on the following curriculum content areas: a systems approach; problem-solving and decision-making; energy/environmental career-related decisions; holistic lifestyle assessment; ideal environmental worldviews; fundamental concepts of energy; energy resource delivery systems; forecasting, planning, and policy formation; and futures thinking.

The Content Sourcebook also provides a good deal of supportive materials, including:

- o THE USER STRATEGY--describes applications of the EE training models for their intended users; describes the components of an EE curriculum.
- o ENVIRONMENTAL EDUCATION ENTITIES--describes 12 key concept/topic areas interpreted from the EE Act of 1970 and other Office of Environmental Education documents.
- o ISSUES OF NATIONAL PRIORITY--presents narrative descriptions of ten major energy or environmental issues that can provide the basis for the development of EE curricula.
- o SUBJECT MATTER/CULTURAL PROCESS MATRIX--provides a structure for thinking about EE curricula content in terms of: (a) EE principles and concepts; (b) instructional learning resources; and (c) competencies (for the environmentally aware and literate citizen) for each of the various curriculum content areas.
- o A BIBLIOGRAPHY for each of the curriculum content areas, and a GLOSSARY are provided.

The Energy-Focused Environmental Education Teacher Training Units

The four units (or "modules") in this series comprise a basic set of introductory materials consistent with the need described in the EE Act. These units were derived from the High School Teacher Training Model--described above--that was developed by the Far West Laboratory in 1977. This model provided a rationale and guideline for developing teacher training materials that foster a holistic understanding of our natural- and human-fashioned environment and for presenting this understanding in the context of environmental issues rather than as a simple presentation of subject matter. Integrated within the four modules are the learning processes that allow teachers to explore the numerous interactions between the systems of humanity and nature and, in so doing, promote their environmental awareness as citizens. Each training unit in the series deals with a different environmental issue. These are described below:

Optimal Use of Finite Land Resources

Teachers will use a carrying capacity methodology to examine finite land resources, population dynamics, and available energies that must be in dynamic equilibrium in order to maintain a stable balance between the needs of urban and agricultural systems as they develop and grow, and the needs of natural systems to maintain ecological integrity.

Energy-Intensive Urban Growth and the Quality of Life

Teachers will examine the pattern of U. S. urban growth as influenced by economic and other considerations and compare these with considerations for enhancing the quality of life. They will examine the potential of current urbanization to reverse its present trend toward high energy costs with decreasing quality of life for urban society. They will also examine the implications of envisioned future patterns or urbanization on energy costs and the quality of life.

Energy-Conserving Resource Utilization

Teachers will compare a variety of energy conservation strategies and their contributions in terms of a stewardship approach to resource utilization and conservation. They will analyze the conservation recommendations of the National Energy Plan and act as a Task Force Committee to propose conservation measures for a local community.

Energy Resource Delivery and Use

Teachers will examine the role of energy in changing cultural contexts. They will study the nature and uses of various conventional and nonconventional energy resources, examine the dimensions of energy policy making, and evaluate the implications of differing means of energy delivery in terms of technical efficiency, and environmental and social impacts. They will also apply holistic criteria to the evaluation of an energy policy plan.

Each training unit or module follows a similar presentation format:

- An INQUIRY section that presents the facts, concepts, and principles associated with an energy-environmental issue. This section includes text, readings, and activities.
- An INTEGRATION section that presents a planning and decision-making simulation involving the issue in a practical setting.
- An APPLICATION section that presents a set of general guidelines for planning and implementing instructional units emphasizing the issue.

Further Information

For further information on any of these documents or materials, write to:

Bela H. Banathy
Executive Research Director
Far West Laboratory for Educational Research and Developmen
1855 Folsom St.
San Francisco, CA 94103

Ordering Materials

To order materials, write to

National Teaching Systems
1137 Broadway
Seaside, CA 13955

Approximate Prices

EE Teacher Training Models:

High School Teachers	$6.00
Natural Science Teachers	$6.00
Social Science Teachers	$6.00
Community Leaders	$6.00

EE Content Sourcebook	$12.00
Energy-Focused EE Teacher-Training Units	
Optimal Use of Finite Land Resources	$8.00
Energy Intensive Urban Growth and Quality of Life	$8.00
Energy-Conserving Resource Utilization	$8.00
Energy Resource Delivery Use	$8.00

* The foregoing section (with minor editing) was furnished by The Far West Laboratory for Educational Research and Development. We appreciate their furnishing this material.

Distribution

Copy No.	
1 - 6	Mr. Walter Bogan, Director Office of Environmental Education 400 Maryland Ave. S. W. FOB #6, Room 2025 Washington, D. C. 20202
7 - 8	Mr. George Coates Office of Environmental Education 400 Maryland Avenue S. W. FOB #6, Room 2025 Washington, D. C. 20202
9	Dr. Alexander Christakis University of Virginia Engineering Science and Systems Department Room 234 A & M Building
10	Bro. Raymond Fitz Office of the President University of Dayton Dayton, Ohio 45469
11	Dr. H. Grant Goodell Department of Environmental Sciences Clark Hall University of Virginia
12	Dr. R. W. House Box 6188, Station B School of Engineering Vanderbilt University Nashville, Tennessee 37235
13	Dr. Robert Waller Department of Business University of Northern Iowa Cedar Falls, Iowa 50613
14	Office of Sponsored Programs Madison Hall University of Virginia
15 - 24	J. N. Warfield Department of Electrical Engineering University of Virginia

Distribution (cont.)

25 - 26 MS E. H. Pancake
Science/Technology Information Center
Clark Hall
University of Virginia

27 RLES files

28 Professor Robert Stake
CIRCE
College of Education
University of Illinois
Urbana, IL 61801

29 Dr. Tom Hastings
CIRCE
College of Education
University of Illinois
Urbana, IL 61801

30 Dr. Bela Banathy
Far West Laboratory
1855 Folsom Street
San Francisco, CA 94103

UNIVERSITY OF VIRGINIA

School of Engineering and Applied Science

The University of Virginia's School of Engineering and Applied Science has an undergraduate enrollment of approximately 1,300 students with a graduate enrollment of approximately 500. There are 125 faculty members, a majority of whom conduct research in addition to teaching.

Research is an integral part of the educational program and interests parallel academic specialties. These range from the classical engineering departments of Chemical, Civil, Electrical, and Mechanical and Aerospace to departments of Biomedical Engineering, Engineering Science and Systems, Materials Science, Nuclear Engineering and Engineering Physics, and Applied Mathematics and Computer Science. In addition to these departments, there are interdepartmental groups in the areas of Automatic Controls and Applied Mechanics. All departments offer the doctorate; the Biomedical and Materials Science Departments grant only graduate degrees.

The School of Engineering and Applied Science is an integral part of the University (approximately 1,530 full-time faculty with a total enrollment of about 16,000 full-time students), which also has professional schools of Architecture, Law, Medicine, Commerce, and Business Administration. In addition, the College of Arts and Sciences houses departments of Mathematics, Physics, Chemistry and others relevant to the engineering research program. This University community provides opportunities for interdisciplinary work in pursuit of the basic goals of education, research, and public service.